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Sky and TELESCOPE

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Vol. XVIII, No. 5 MARCH, 1959

CONTENTS

COVER: The Academy Planetarium of the new Air Force Academy in Colorado Springs, Colorado, was formally dedicated on January 26th. The 50-foot dome houses a Spitz Model B projector and accommodates 288 persons. In the immediate background is the administration building. During the Nationwide Amateur Astronomers Convention this August in Denver, a field trip to the academy and planetarium is scheduled for August 29th. (See page 250.)

THE NEW "AMERICAN EPHEMERIS" 239

CHARLES DARWIN AND THE PROBLEM OF STELLAR EVOLUTION — Otto Struve 240

ROCKET PROPELLANTS – THE KEY TO SPACE TRAVEL – II — Frederick I. Ordway, III 244

AMERICAN ASTRONOMERS REPORT 252

SOME ASTRONOMICAL STAMPS – III — Alphonse P. Mayernik .. 256

PLANET NOTES FROM MOSCOW — Joseph Ashbrook 258

AMATEUR ASTRONOMERS 250
Amateur Convention To Tour Air Force Academy

BOOKS AND THE SKY 273
Physics and Philosophy
The Exploration of Time
Advances in Geophysics, Volume 5

CELESTIAL CALENDAR 290

GETTING ACQUAINTED WITH ASTRONOMY 262
Time and the Sky – III

GLEANINGS FOR ATM's 282
A 4-inch Gregory-Maksutov Telescope
Maksutov Telescope Notes

NEWS NOTES 249

OBSERVER'S PAGE 267
January's Great Sunspot Group
Deep-Sky Wonders

OBSERVING THE SATELLITES 260

PLANETARIUM NOTES 264

QUESTIONS 251

SOUTHERN STARS 292

STARS FOR MARCH 293

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The New "American Ephemeris"

YEAR AFTER YEAR, one of the best sellers among astronomical books has been a substantial dark blue volume issued by the Nautical Almanac Office of the U. S. Naval Observatory. Both the professional astronomer and the serious amateur find it a valuable reference work in planning and analyzing observations.

Beginning with the volume for 1960, *The American Ephemeris and Nautical Almanac* has been greatly changed and improved, with an arrangement that differs considerably from that of 1959 and earlier years. This work and the *British Nautical Almanac* have been unified, the same book being simultaneously published in the two countries.

A major change concerns the predicted positions of the sun, moon, and planets. Before 1960, they were listed for specified instants of Universal time (standard time of Greenwich). However, Universal time is affected by slight irregularities caused by the nonuniform rotation of the earth. Therefore, in 1960 and thereafter, *Ephemeris time* is used instead. This is a uniformly flowing time, differing slightly from Universal time by an amount that changes from year to year. The practical rule for obtaining Ephemeris time is, for 1960, to add 35 seconds to the UT.

Particularly welcome to the amateur is the greatly enlarged, redesigned section on planetary phenomena, now placed on pages 4 to 9 of the 1960 volume. Here is presented much information for observers with the unaided eye, binoculars, and small telescopes. Included are lists of occultations of 1st-magnitude stars by the moon, and data on the brightnesses of planets and the first four asteroids. The month-by-month diary of planetary configurations is very easy to use, as the symbols for the planets and their aspects have been replaced by the names themselves.

The diagrams of the configurations of Jupiter's four bright moons are in a new form, with their changing positions shown by curves instead of at daily intervals. There is a two-page map of the November 7, 1960, transit of Mercury, and it is evident at a glance that this event will be visible throughout the Americas. Henceforth, the *American Ephemeris* will carry predictions of penumbral lunar eclipses.

The ephemerides for the physical observations of the planets have been improved, and Saturn is included for the first time. But detailed station predictions of occultations of stars have been omitted. It is planned, however, to publish those for the United States and Canada in SKY AND TELESCOPE.

The 1960 *American Ephemeris* is sold by the Superintendent of Documents, Washington 25, D. C., for $4.00.

Charles Darwin and the Problem of Stellar Evolution

OTTO STRUVE, *Leuschner Observatory, University of California*

THIS YEAR the entire world will mark the hundredth anniversary of the publication (on November 24, 1859) of Charles Darwin's *The Origin of Species*. In many ways, the status of evolution in biology during the years just before Darwin's book appeared resembles the present state of the problem of stellar evolution. Only a few changes are needed in the following words from Darwin's *Autobiography** to make them apply to modern astronomy:

"It has sometimes been said that the success of the *Origin* proved 'that the subject was in the air,' or 'that men's minds were prepared for it.' I do not think that this is strictly true. . . . What I believe was strictly true is that innumerable well-observed facts were stored in the minds of naturalists ready to take their proper places as soon as any theory which would receive them was sufficiently explained."

Just as in astronomy today, so in biology 100 years ago, the hypothesis of evolution was being very seriously considered. For example, Darwin in 1857 wrote to A. R. Wallace: "By your letter and even still more by your paper in the Annals, a year or more ago, I can plainly see that we have thought much alike and to a certain extent have come to similar conclusions."

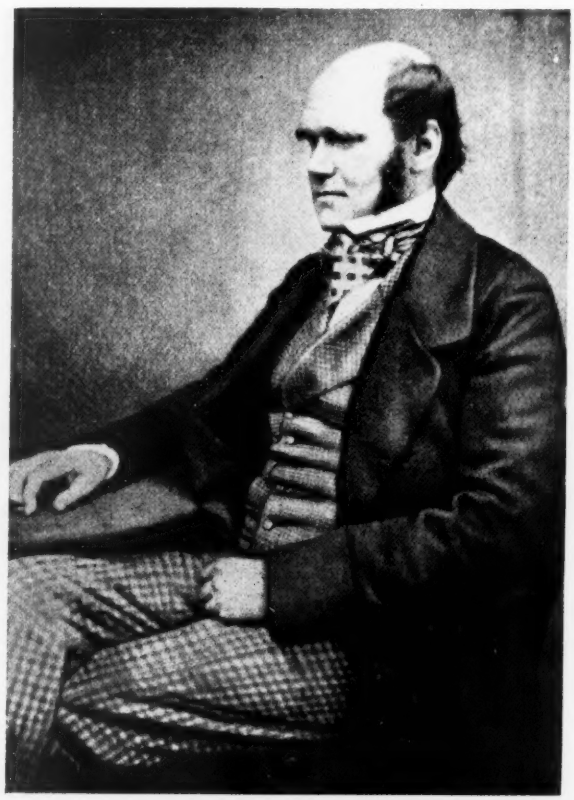
Both of these discoverers of evolution showed the true generosity of creative minds. Darwin offered to refrain from publishing his own results to recognize Wallace's priority in preparing a paper for publication. Wallace later wrote ". . . I have not the love of *work, experiment* and *detail* that was so pre-eminent in Darwin, and without which anything I could have written would never have convinced the world."

Charles Lyell and Sir Joseph Hooker arranged for a joint paper by Darwin and Wallace to be presented at the Linnean Society in London on July 1, 1858. This paper paved the way for the form in which *The Origin of Species* reached the public a year later. Darwin tells in his *Autobiography:* "Another element in the success of the book was its moderate size; and this I owe to the appearance of Mr. Wallace's essay; had I published on the scale in which I began to write in 1856, the book would have been four or five times as large as the *Origin*, and very few would have had the patience to read it."

Astronomers who are now working on the problem of stellar evolution may also be interested in Darwin's modest appraisal of himself: ". . . my success as a man of science, whatever this may have amounted to, has been determined, as far as I can judge, by complex and diversified mental qualities and conditions. Of these, the most important have been — the love of science — unbounded patience in long reflecting over any subject — industry in observing and collecting facts — and a fair share of invention as well as of common-sense. With such moderate abilities as I possess, it is truly surprising that I should have influenced to a considerable extent the belief of scientific men on some important points."

They might also remember what T. H. Huxley once wrote in connection with Darwin's work on barnacles. "The great danger which besets all men of large speculative faculty is the temptation to deal with the accepted statements of fact in natural science, as if they were not only correct, but exhaustive; as if they might be dealt with deductively, in the same way as propositions in Euclid may be dealt with. In reality, every such statement, however true it may be, is true only relatively to the means of observation and the point of view of those who have enunciated it. So far it may be depended upon. But whether it will bear every speculative conclusion that may be logically deduced from it, is quite another question. . . . [Darwin] knew of his own knowledge the way in which the raw materials of these branches of science are acquired, and was therefore a most competent judge of the speculative strain they would bear."

It would be presumptuous to claim that anything like *The Origin of Species* has yet been written in the field of stellar evolution. But its raw materials, in Huxley's sense of the words, may be said to exist in the magnificent book *Stellar Structure,* edited by S. Flügge, and forming Volume 51 of the *Handbuch der Physik*. Of especial interest are two of its chapters, one by G. R. and E. Margaret Burbidge on what they call "the chemical evolution of stars," the other by L. H.



The great British naturalist Charles Darwin (1809-1882), during the period of his life when he was writing "The Origin of Species," published 100 years ago this coming November. His great accomplishment was to collect and analyze an enormous body of facts about living creatures, finding a consistent over-all pattern that was the basis for a theory of organic evolution. In astronomy today, our factual information about the stars has grown to nearly the point where an astrophysical Darwin could construct the science of stellar evolution.

*A paperbound edition, entitled *The Autobiography of Charles Darwin and Selected Letters*, of a book edited by Francis Darwin in 1892 has recently been published by Dover Publications, Inc., 920 Broadway, New York 10, N. Y., and is the source of the quotations in this article.

Aller on the abundances of the elements in the sun and stars. (The entire Burbidge article, with 153 pages and a list of 465 references, is really a book in itself.)

These two articles are among the most inspiring scientific summaries I have encountered. Yet, the Burbidges have had to use on almost every page such phrases as "may be," "probably are," "it is conceivable," and "might account for." Clearly the raw material of the observations is not yet strong enough to withstand the "speculative strain" that the interpreter wishes to impose on it.

Only 10 years ago, astrophysicists could legitimately doubt the reality of practically all the reported discrepancies in the cosmic abundances of the elements, except for hydrogen. In the meantime, as M. Minnaert has pointed out, there has been a clear change in the general attitude. Because we now know of nuclear processes occurring inside the stars and even at their surfaces, it is evident the abundances of the elements may change in the course of stellar evolution, and differences in composition among stars have become accepted.

In the Burbidges' list of theoretically predictable nuclear processes in stars, the most important appear to be:

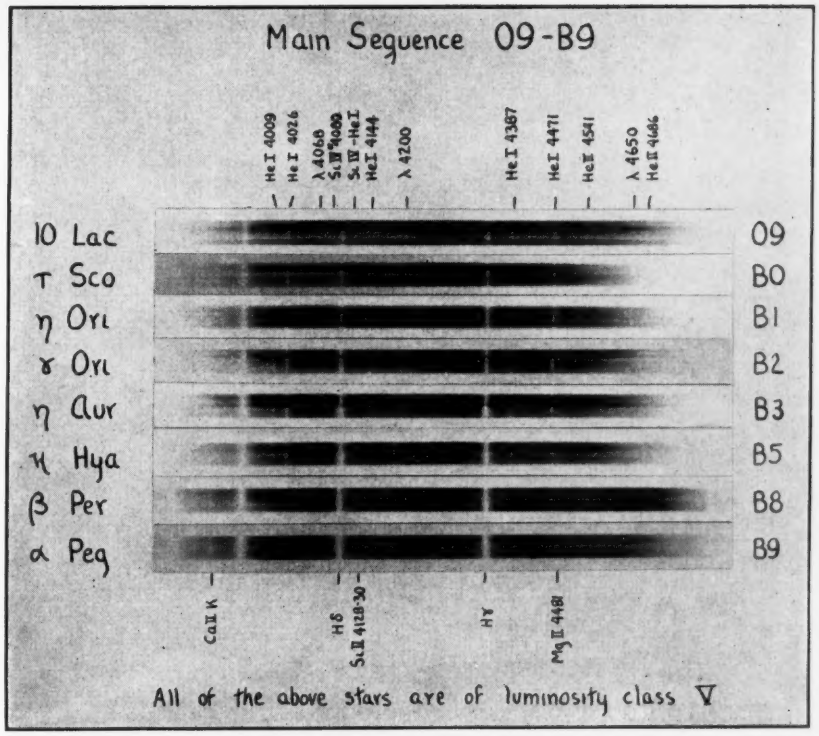
Hydrogen-burning. By proton-proton reactions and the carbon cycle, hydrogen (H) can be converted to helium (He) at relatively low temperatures, around 15 to 20 million degrees, and at densities of the order of 100 grams per cubic centimeter. This hydrogen fusion accounts for the radiation from most of the stars at the present time.

Helium-burning. Helium can be converted into the atomic nuclei C^{12}, O^{16}, Ne^{20}, and Mg^{24} (the superscripts indicate atomic masses), by successive fusions of helium nuclei (alpha particles). For this, temperatures of about 100 million degrees and densities of about 100,000 are needed, and gamma rays are emitted.

The α-process. At temperatures of one billion degrees, high-energy gamma radiation becomes so abundant that it can disrupt nuclei already formed by the helium-burning process, which has used up all the available helium. Thus, a gamma ray colliding with a Ne^{20} nucleus produces O^{16} and He^4. The new alpha particles can successively build up elements from Mg^{24} to Ti^{48}.

The e-process. This begins to operate when the temperature is about three billion degrees, at densities of 10^4 to 10^6 grams per cubic centimeter. A great profusion of reactions will occur in a very short time, building up elements which form the so-called iron peak in the abundance curve, a large proportion of the material being converted to Fe^{56}. The Burbidges write:

"Thus the star may evolve to a configuration with an iron core. Surrounding this, if no mixing takes place, will be a layer consisting of material made in the α-process, while outside this will lie a helium-burning zone, and finally a hydrogen-burning zone. To what extent this would represent a stable configuration is not known."



The spectra of eight main-sequence stars of types O9 to B9 are reproduced from "An Atlas of Stellar Spectra," by Morgan, Keenan, and Kellman. While the hydrogen lines strengthen from O9 to B9, and the helium lines are strongest at B2, these differences are due to temperature effects and not to element abundances. The actual chemical analysis of a star must carefully allow for the effects of temperature and pressure in its atmosphere. Yerkes Observatory photograph.

Other processes discussed in the *Handbuch* article are those involving neutron capture in red giant stars and in supernovae, producing heavier elements, and the formation of the cosmically rare light elements, deuterium, lithium, beryllium, and boron, possibly in solar and stellar flares.

All of the principal processes can occur only in the deep interior of a star. But we know that near the centers of the sun and all other main-sequence stars the temperatures and densities suffice only for hydrogen-burning. Thus, in their interiors hydrogen is being converted to helium, but no other elements are being synthesized. If any of the other processes occur at all, it must be in giant and supergiant stars.

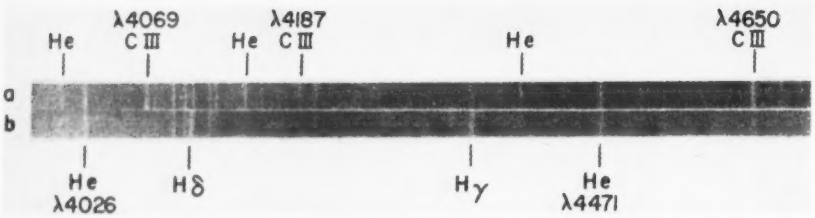
Do we have any direct observational evidence that the hydrogen-burning process is actually going on in stars? When we turn to the results of spectroscopists who have determined the abundances of various chemical elements in stellar atmospheres, we encounter some striking inconsistencies.

Since the sun is about 5,000 million years old, we might expect that a considerable portion of its original supply of hydrogen has already been converted to helium. Yet, if we compare the abundances of elements in the solar atmosphere and in the gaseous nebulae — from which the sun presumably condensed five billion years ago — they are the same, to within the precision of our measurements!

This result is partly explained by the slowness with which the sun operates as an atomic reactor; perhaps even at its age the sun has not had enough time to convert much hydrogen to helium. Furthermore, the helium production changes the composition of the solar core only; and the convection currents inside the sun must be too slow for much of this helium to have reached the surface.

Next let us compare the atmospheric compositions of hot, early-type main-sequence stars with the gaseous nebulae. These *O* and *B* stars are young, perhaps only 100 million years old. Evidently, their original composition must have been very similar to that of the presently observed gaseous nebulae. But energy production in such stars proceeds some 10,000 times faster than it does in the sun, and hydrogen depletion in the interiors of most of them should be even further advanced.

Nevertheless, Aller's work shows that their atmospheres have the same composition as the nebulae. Apparently, in this case also, mixing has been ineffective in



HD 160641 is a 10th-magnitude O-type star in Scorpius, noteworthy for its low hydrogen content, but lines of helium and doubly ionized carbon are conspicuous in its spectrum (a). (Those near the Hγ and Hδ positions are from ionized helium.) For comparison, the normal O-type supergiant Alpha Camelopardalis is shown also (b). These McDonald Observatory spectra and those below were taken by W. P. Bidelman. From the "Astrophysical Journal."

bringing internally produced helium to the surface. This is surprising because these very luminous, hot stars are unstable; their spectra often show emission lines produced in detached gaseous rings, and other indications of violent currents of gas in the outermost layers.

If the mixing in main-sequence stars of early spectral type is really very slow, we should examine the chemical abundances in old, hot stars from which the outer layers have been stripped, leaving stellar "stumps" enriched with helium at the expense of hydrogen.

The best example of such a star is the bright component of the eclipsing binary Beta Lyrae. As told in SKY AND TELESCOPE for July, 1957, page 418, this *B*8-type giant star expels a stream of gas toward the other component, thereby losing mass at the rapid rate of about 5×10^{22} grams per second. If this process has operated long enough, much of the star's outer layer should have already been dissipated into space, and the stump might show helium enrichment.

As yet no detailed study of the abundances of elements in this star has been made. However, the spectrograms appear to have no striking difference in the hydrogen-to-helium (H/He) ratio between it and other normal stars or gaseous nebulae. Evidently, either there has not been enough mixing to enrich the presumably exposed surface, or the bright component of Beta Lyrae is not old enough to have produced enough helium.

We are led to consider still older stars, for example the Beta Canis Majoris variables, discussed in my article on page 74 of last December's issue. They are old enough to have moved appreciably to the right from the main sequence in the Hertzsprung-Russell diagram. According to the theory of stellar interiors, this can happen only if a large fraction of the internal supply of hydrogen has already been converted to helium.

The abundances of elements have been determined by Aller for several stars of this type: σ Scorpii, 15 Canis Majoris, ξ, Canis Majoris, δ Ceti, and γ Pegasi. It turns out that the atmospheres of these stars show about the same H/He ratio as do the ordinary main-sequence stars like 10 Lacertae and τ Scorpii. Nevertheless, their spectra are not normal in all respects; for example, the lines of ionized oxygen and ionized nitrogen are very strong.

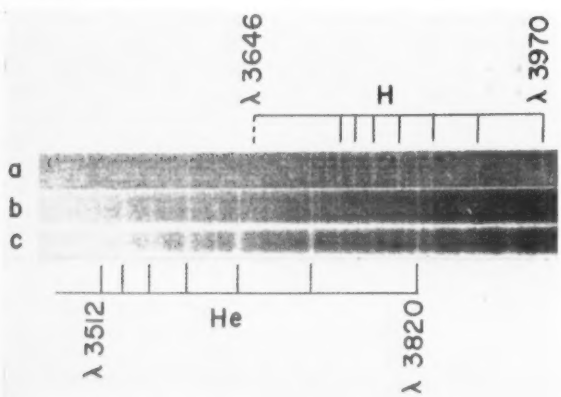
What about stars of very early spectral type in galactic clusters whose upper main sequences depart from the zero-age sequence? The brighter members of the Pleiades are such stars, but their spectral lines are broadened by very rapid rotation. The only exception is Maia, whose hydrogen lines are weak, whereas lines of He I, Mn II, and Fe II are strong. Moreover, W. W. Morgan found on low-dispersion spectrograms that all the brighter Pleiades show weaker hydrogen lines than would be expected from spectral types assigned in accordance with the ratio of He I to Mg II. As I pointed out in 1950, caution is needed in interpreting this result, but it may be suggested, with great reservation, that we have found some indication of hydrogen-burning in the brighter Pleiades stars. They are fairly old for their spectral types, and their very rapid rotations may hasten mixing.

The evidence provided by other galactic clusters — some of which are considerably older than the Pleiades — is quite inconclusive with regard to the H/He abundance ratio. It is true that many strange differences between the metallic-line stars in clusters and normal *F* stars have been found by J. L. Greenstein and others. But some investigators have attributed them to structural differences rather than to actual dissimilarity in chemical composition.

Since we have found little or no evidence of hydrogen-burning in those stars that might have been expected to show it, we next turn to the oldest known stars in our galaxy, those in globular clusters. Here we are faced with another surprise. Their spectra often have an abnormally large ratio of hydrogen to metals. Because such stars are too cool to show helium lines, we cannot measure H/He directly, but if hydrogen is depleted in their atmospheres the hydrogen-to-metals ratio should be small, not large.

Because we are fully committed to the idea that hydrogen-burning has been taking place, it has been suggested that the original medium out of which the globular-cluster stars were formed was much richer in hydrogen, relative to metals, than is the case in, say, the Orion nebula at the present time. We argue that a star sheds a large part of its mass before it becomes a white dwarf. Thus, the interstellar gas out of which new stars are continually being formed is gradually being enriched with helium and metals. Stars of the first generation (in globular clusters) may have originally consisted almost entirely of hydrogen, while those of later generations (like the sun and especially the hot main-sequence objects) consisted initially of a mixture of hydrogen and other elements.

What about the H/He and H/metals abundance ratios in the atmospheres of other stars of apparently very great evolutionary age? (In actual years, some may be much younger than globular-cluster stars.) Here the evidence is definitely positive. Observations by D. M. Popper,

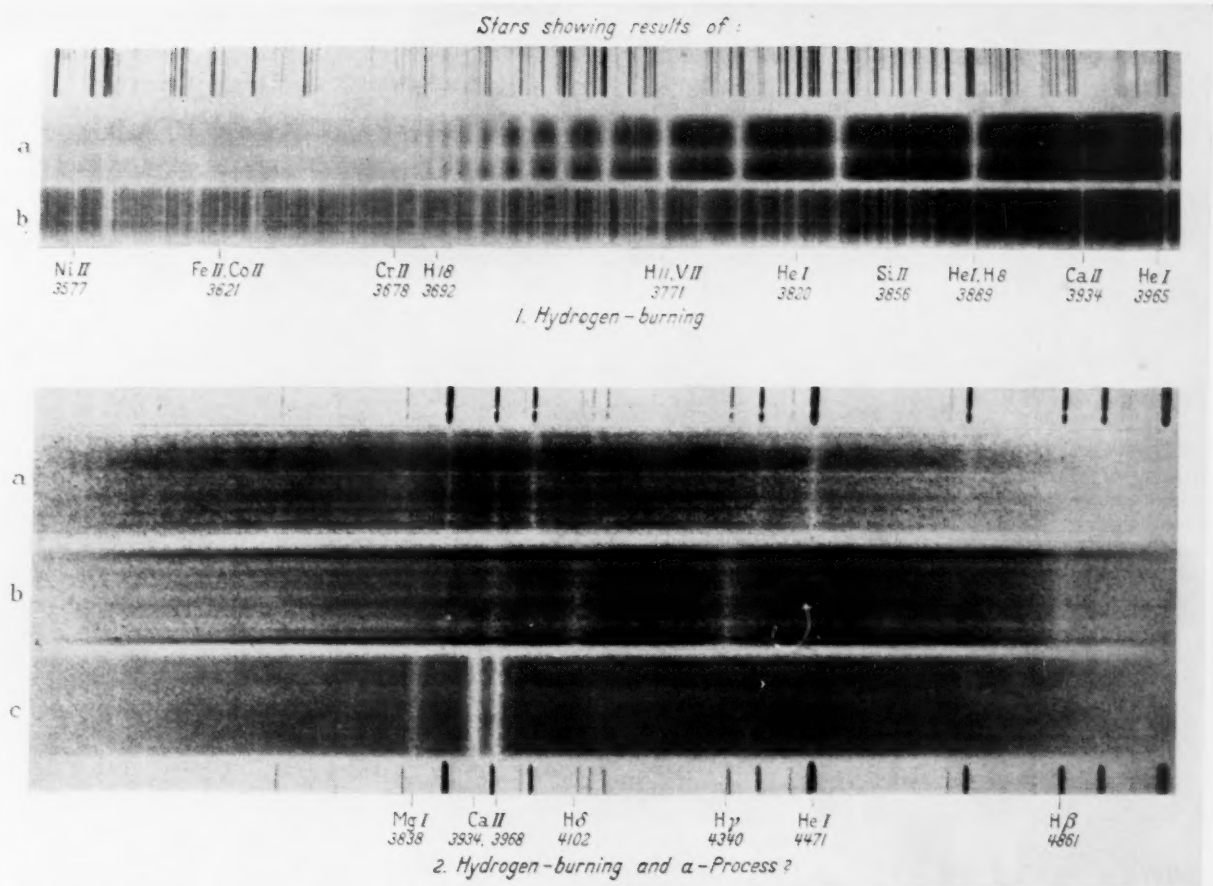


Portions of the ultraviolet spectra of three O and B stars, taken by W. P. Bidelman. At (a), Kappa Cassiopeiae has a normal abundance of hydrogen, while the others, HD 160641 and HD 124448 (b and c respectively), lack hydrogen lines but are rich in helium.

COMPARISON OF ABUNDANCES

Element	*Cosmic Abundance*	*Young Stars*	*Very Old O-B Star*
Hydrogen	75.5%	58.6%	0%
Helium	23.3	39.8	95.4
Carbon	0.080	0.10	0.31
Nitrogen	0.17	0.17	0.47
Oxygen	0.65	0.48	0.75
Neon	0.32	0.73	3.00
Silicon	0.053	0.08	0.065

In this table, the abundances are given in percentages of total mass. The average cosmic abundances are according to H. E. Suess and H. C. Urey, the stellar according to L. H. Aller and G. Traving. The young stars are Tau Scorpii and 10 Lacertae, and the very old star is the subdwarf HD 160641, for which preliminary abundances are given.



The Burbidges selected these spectra by J. L. Greenstein to illustrate abundance differences among stars. At the top, a normal A-type star, Eta Leonis (a), is compared with the hydrogen-deficient Upsilon Sagittarii (b), which has strong helium lines. In the lower part, showing three white dwarfs, (a) L1573-31 has helium lines but none of hydrogen; (b) L770-3 has broad, weak lines of hydrogen only; and (c) Ross 640 has strong ionized calcium lines and a magnesium line only. Of these five spectra, the top two were taken with the 82-inch McDonald reflector, the others with the 200-inch Hale telescope. This illustration appears in Volume 51, "Handbuch der Physik," published by Springer-Verlag, Berlin.

W. P. Bidelman, A. D. Thackeray, Aller, G. Münch, Greenstein, and others have shown that several hot subdwarf stars have practically no atmospheric hydrogen, but an enormous amount of helium, and sometimes much more neon than carbon. The table is from the Burbidges' article. These well-evolved hot stars give the first unassailable evidence that reaction products from the hydrogen- and helium-burning processes have reached the observable surfaces of the stars.

Not all star groups of approximately the same evolutionary age have equally hydrogen-deficient atmospheres. The central stars of planetary nebulae are very old, and their spectra sometimes have weak hydrogen lines, but the H/He ratio is usually much less anomalous than in the *O*- or *B*-type subdwarfs. Moreover, Aller tells us that their enveloping nebulae seem to have normal compositions. Of course, the nebulae may have become heavily contaminated with interstellar gas of normal composition. Still the evidence is not conclusive.

The novae are quite certainly old stars, yet their spectra have fairly strong hydrogen lines. It may be that their outermost layers are still essentially uncontaminated by the reaction products, while the blue *O-B* subdwarfs may have already shed their envelopes. But I fear that I am beginning to use words like "may be" even oftener than the Burbidges' article does!

All astronomers will agree that the white dwarfs are even older, in an evolutionary sense, than any of the other stars we have been discussing. They have shed their outer layers in novalike outbursts and show only their hydrogen-deficient stumps. Many white dwarfs have spectra with no hydrogen lines, or very weak ones. In the accompanying photographs by Greenstein of white-dwarf spectra, one does show broad hydrogen lines, and there are some others, such as the companion of Sirius, with strong hydrogen lines. It has been argued that this comes from the accretion of interstellar gas, forming a thin layer of hydrogen on top of a virtually hydrogen-free star. Because of the enormous surface gravity of the white dwarfs, this layer would be only something like one millimeter thick.

There are some other stars whose atmospheres are strikingly deficient in hydrogen and rich in helium. Two of these are Upsilon Sagittarii and HD 30353, both supergiants, probably of large mass. The former has little hydrogen, while not only helium but nitrogen, neon, sulfur, and argon are probably greatly overabundant. This strongly suggests that the reaction products of hydrogen- and helium-burning are present, and those of the α-process as well.

It is puzzling that these particular supergiants show anomalous abundances, while others like Deneb and Rigel do not. The Burbidges tentatively suggest that, because Upsilon Sagittarii and HD 30353 are spectroscopic binaries, mass loss and mass exchange may have helped strip off their envelopes.

There are many other possible spectroscopic effects that depend on the chemical evolution of the stars. Taken separately, each is fairly convincing. However, they do not yet fit together into one over-all pattern of evolutionary change in stellar spectra. The time is not quite ripe for an astronomical *Origin of Species*.

ROCKET PROPELLANTS—
The Key to Space Travel—II

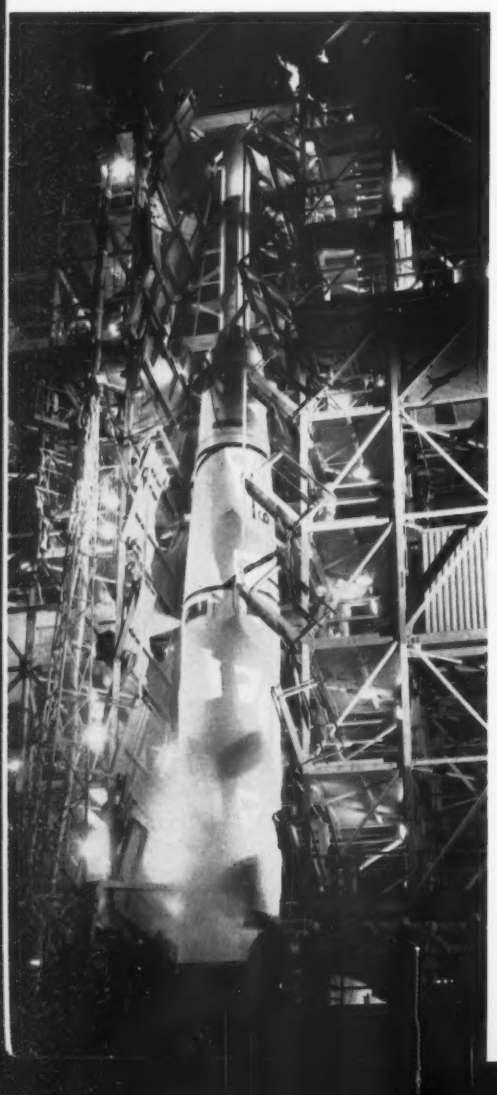
FREDERICK I. ORDWAY, III, *General Astronautics Corporation*

IN THE FIRST PART of this article, we discussed especially some of the characteristics of solid propellants for use in modern rockets. Next we consider liquid fuels, then we turn to other proposed methods of rocket propulsion, some of them unconventional and speculative.

Liquid Fuels. When long-distance rocket flight is needed, engineers have generally employed liquid propellants, which have many advantages. They can be carried in separate, detachable light-weight tanks under low pressure, and the combustion chamber into which they are fed can be much smaller and more efficient than for solid propellants.

Like solids, however, liquids have their limitations. Thermodynamic calculations show that their highest attainable specific impulse is only about twice the value engineers work with today. Liquid propellants offer specific impulses ranging from about 150 to perhaps 400 pound-seconds per pound, the exact value for a particular case depending on the pressure in the combustion chamber.

Whatever combination of rocket motor and liquid fuel we use, it is never possible to exploit 100 per cent of the available energy, because of incomplete combustion, heat losses to the chamber walls, and kinetic energy carried away in the exhaust gases themselves. As a rule, only about 60 per cent of the heat content of the combustion materials is actually converted into directed kinetic energy that drives the rocket forward.



Launching a liquid-fuel rocket is a complex operation, as shown by this view of Pioneer III in its gantry being readied for its moonward flight last December. It is also seen in a picture on page 246. U. S. Air Force photo.

The desirable properties to be sought in a liquid propellant are high heat of combustion, high reaction rate, and low molecular weight of the combustion particles. One of the theoretically best systems uses liquid hydrogen and liquid oxygen, providing a specific impulse of about 360 pound-seconds per pound. The table compares its characteristics with those of some other combinations of fairly stable liquid fuels and oxidizers.

Generally, as the molecular weight of the exhaust gases goes down, the specific impulse increases. Today we work with molecular weights in the region of 20, but hope eventually to be using values around 10. High temperature is desirable, for the thermal energy is converted to kinetic energy of the rocket as the combustion products escape from the nozzle.

In practice, it is necessary to balance low molecular weight against high temperature to reach the highest practicable specific impulse. It is unlikely that temperatures much above 7,000° Fahrenheit will be used. Some reactions do produce up to nearly 11,000°, but the molecular weights of the combustion products are rather high. There is a cyanogen-liquid-ozone system under study at Temple University providing a combustion temperature over 15,000°.

We can anticipate the use of oxidizers with increased fluorine content. As the most powerful oxidizer known, fluorine has long interested propellant chemists, but only recently has it become feasible to produce it in quantity. Fluorine reacts with most substances, providing high heats of reaction. Among the fluorine compounds being studied as oxidizers are oxygen fluoride, chlorine trifluoride, and bromine pentafluoride.

There will probably be more use of the light elements — including lithium, beryllium, and boron — as constituents of rocket propellants, in such compounds as beryllium borohydride, lithium borohydride, lithium aluminum hydride, boron triethyl, and beryllium dimethyl. Methyl hydrides and organometallic compounds offer higher exhaust velocities than do straight hydrocarbon fuels. Among the higher-energy systems receiving careful study are those using amine fuels (hydrazine, ammonia) and liquid halogens.

Chemical reactions with such materials as these place extreme demands on combustion chamber materials, which can now withstand temperatures as high as

CHARACTERISTICS OF LIQUID PROPELLANTS

Combination	*Specific Impulse*	*Chamber Temperature*	*Combustion Products*
Red fuming nitric acid-aniline	210	5,065	25
Nitric acid-ammonia	237	4,220	21
Red fuming nitric acid-unsymmetrical dimethylhydrazine	249	5,200	22
Liquid oxygen-alcohol	259	5,560	22
Hydrogen peroxide-hydrazine	262	4,690	19
Liquid oxygen-gasoline	263	5,770	22
Nitrogen tetroxide-hydrazine	263	4,950	19
Liquid oxygen-hydrazine	280	5,370	18
Oxygen difluoride-ammonia	295	6,380	18
Liquid oxygen-hydrogen	364	4,500	9
Fluorine-hydrogen	373	5,100	9

Units: *Specific Impulse*, pound-seconds per pound at a chamber pressure of 500 pounds per square inch; *Chamber Temperature*, degrees Fahrenheit; *Combustion Products*, average molecular weight.

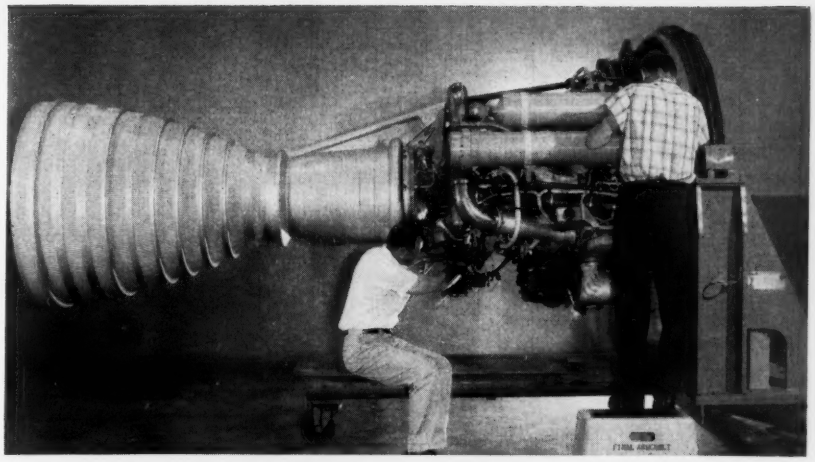
6,000° F. and pressures of some 1,000 pounds per square inch. Many special alloys, metals, coatings, and ceramics are being studied at present. The effects of elevated temperatures on these materials are being investigated with solar furnaces, plasma jets, electric arcs, and electromagnetic accelerators.

Higher temperatures can be tolerated if some means are found to reduce the heat flux into the walls of the combustion chamber. Eventually we may have to handle temperatures of up to 9,000°. These problems are closely related to those of the re-entry of ballistic missiles into the earth's atmosphere, in which temperatures of 10,000° to 15,000° may occur at the surface of the vehicle.

If a rocket engine is designed only for operation in empty space, however, the chamber pressure can be lower, for there is no opposing atmospheric pressure to be overcome. This should permit important savings in the weight of the thrust chamber and the propellant-supply system. Of course, the pressure in the chamber should not be so low as to reduce thrust unduly, or to permit incomplete combustion, which would lessen the specific impulse. The proper choice of pressure is a complicated compromise.

Probably the upper limit of specific impulse to be obtained from liquids will be around 375 pound-seconds per pound, with a fluorine-hydrogen system. This appears to be the limit insofar as stable molecules are concerned, from which the energy is obtained by breaking valence bonds.

Why are rocket engineers using propellants with specific impulses around 200 to 250 if values up to 375 appear available? There are many reasons, not the least being that long experience is needed to exploit a new system fully. Specific impulse and molecular weight are not the only factors dictating the choice of a propellant. We must also consider the vapor pressure, low-temperature properties, stability of the fuel against heat and shock, corrosiveness, fire and personnel hazards, toxicity, storage problems, cost, availability, and manufacturing problems. Much experimental work is needed, and there is often a long lag between successful laboratory tests and field use.



A Thor liquid-propellant rocket engine being checked before shipment from Rocketdyne's plant at Neosho, Missouri. This type of engine was used for the Air Force lunar probe that traveled 71,000 miles from the earth.

Consider just one of these factors, thermal stability. This will be a particularly important problem with manned rockets. It is always necessary to compromise between high performance and sensitivity, and some seemingly attractive propellants have either not seen practical use or have had to be rejected altogether.

Free Radicals and Other Exotic Fuels. The term "exotic fuel" has been applied rather indiscriminately to fuels and combinations that are unusually difficult to put into practical use. Fluorine as an oxidizer has been called exotic in many trade journals. Yet the carrier rockets of the Russian satellites may already have used some sort of exotic propellant.

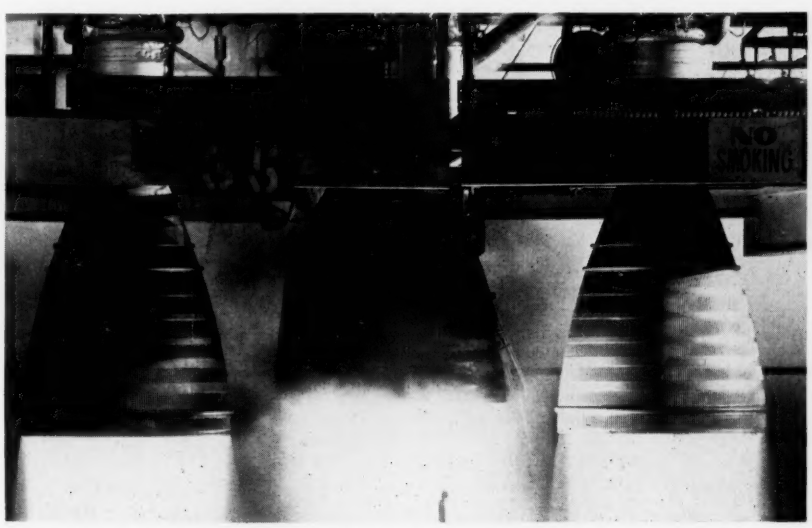
Free radicals have, perhaps, the most promise, for with them we may eventually get from 10 to 25 times the energy per pound of propellant possible with conventional chemicals, and it may be possible to realize specific impulses five times as great as today. A free radical is a fragment of a molecule, and it will attempt to combine with another radical to form a stable molecule, releasing considerable energy when doing so.

If, for example, ethane (C_2H_6) is broken into ethyl radicals (C_2H_5), heat energy amounting to some 200,000 calories per mole will result upon reassociation. It is possible to obtain high specific impulses (400 or more) by mixing hydrogen with such free radicals as CH or NH. Using atomic hydrogen, we could presumably go beyond the 700-pound-seconds-per-pound mark.

But the lack of stability of free radicals is a great problem. Although relatively easy to make, they are extremely difficult to store. Among the techniques being explored for keeping free radicals from recombining are magnetic suppression, liquid helium baths, and electrostatic separation in mixtures with argon or helium.

Other problems posed by free radicals are their high reaction temperatures and probable short firing times, requiring special attention to the controlled release of their potential energy.

Other exotic fuels include hybrid propellant systems, which use solid fuels and liquid oxidizers, and the jelly propellants. Under the proper pressure and temperature, gasoline to which metallic soaps have been added will become jellied. It was used in incendiary bombs during World War II. This and other jellies, such as stearates, saturated amines, and butyl rubbers, can presumably be flow-



An Atlas propulsion system during a full-power test, sustainer motor in the center (on gimbals), booster motors on the sides (to increase the initial thrust). Photographs on this page are courtesy North American Aviation, Inc.

regulated, and mixture control may become feasible.

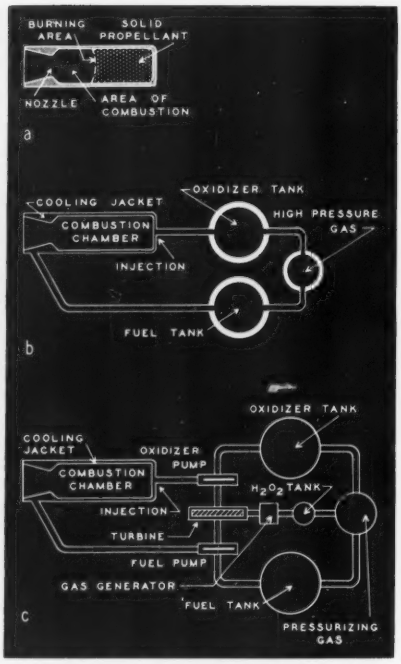
Another possibility is to add a third substance to an oxidizer and jelly fuel to insulate the oxidizer from the fuel so that their reaction cannot occur prematurely. At the proper time an igniter would destroy this insulation, permitting the reaction to take place. The jellies require more powerful feed systems than liquids do, but their densities are better.

Recently the National Cash Register Co. has discovered a method of enclosing liquid particles in microscopic gelatin capsules, which might be applied to liquid rocket propellants to give them some of the advantages of solids.

Ion Propulsion. Rocket experts have long been interested in the possibilities of ion propulsion, in which electrified atomic particles are accelerated by either electric or magnetic fields to obtain very high exhaust velocities.

As was pointed out on page 190 last month, the momentum thrust of a rocket engine is the product of the exhaust velocity and the rate of propellant weight-flow. It is evident that unless enormous quantities of fuel are to be carried on long-range interplanetary flights, we will have to depend upon exhaust velocities being greatly increased over those achieved today with chemical propellants.

Such velocities are possible in an ion-propelled vehicle, the greatest thrust being obtained with charged particles of relatively high mass. The theoretical limit of velocity is the speed of light itself!



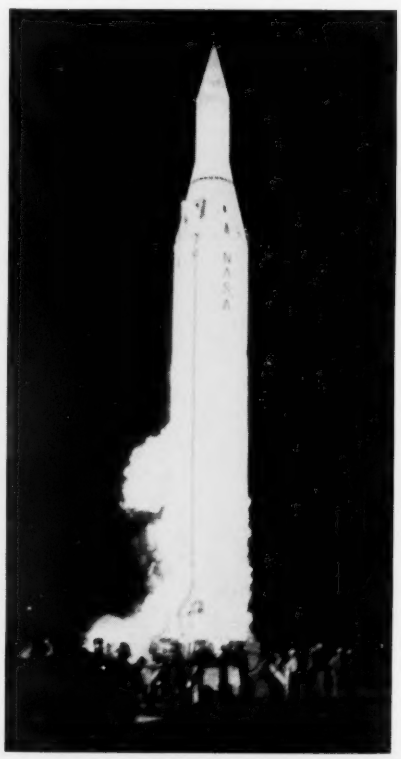
Solid-fuel (a) and liquid-fuel rocket engines (b and c). In b, gas pressure feeds the fuel, while a hydrogen-peroxide-driven turbine is used in c.

Before we can accelerate ions, however, we must produce them. Heating a propellant material to a high temperature would permit ionization, but excessive temperatures or very low pressures are required for most chemical reactions that produce ions, and other methods are believed to be more practical. The solution urged by E. Stuhlinger of the Army Ballistic Missile Agency involves the formation of ions of alkali metals on hot platinum or tungsten surfaces. Other methods include electrical discharges through gases, sending high-frequency electromagnetic radiation through gases, radioactivity, and nuclear fission and fusion.

Of the alkali metals, cesium appears the most attractive, because it has a high atomic weight (133), low ionization potential for its first electron, and low melting and boiling points. (Rubidium, and the more available elements potassium, sodium, and lithium, could be used instead, but they have much lower atomic weights.) When a cesium atom hits a very hot surface, it loses its outermost ring electron and becomes a positive ion, the process having an efficiency of nearly 100 per cent.

In the Stuhlinger proposal, some 1,200 kilowatts of electrical energy would be needed to heat the platinum surface, this energy to come from a turbo-electric generator powered by a nuclear source. The same generator would also provide the power for the accelerating electrostatic field, and the rocket would have a total initial mass of 730 tons (45 for the electric thrust chambers). The Stuhlinger ship would also carry solar batteries to generate auxiliary power for attitude control system, crew quarters, and the like.

Left: Perfecting a large liquid-propellant guided missile, or any rocket system, calls for painstaking design, construction, and flight testing. Here an Atlas intercontinental ballistic missile, number 8-B, is being readied for firing, on September 14, 1958, at Cape Canaveral, Florida. U. S. Air Force photograph.



Right: On the evening of December 5, 1958, Pioneer III was prepared for its flight of 65,000 miles from the earth the next day. The main stage was an Army modified Jupiter intermediate-range ballistic missile, and three solid-fuel stages completed the 60-ton vehicle. This rocket was under the technical administration of the National Aeronautics and Space Administration. U.S. Army photograph.

With this liquid-propelled rocket aircraft, the X-15, North American Aviation test pilot Scott Crossfield was scheduled in February to try to attain an altitude of 100 miles in the ionosphere, and speeds up to a mile a second. His specific mission was to test the complex conditions of re-entry into the atmosphere. Plans for the 50-foot-long vehicle were drawn up by the U. S. Air Force, the Navy, and NASA. The photographs on this page are from North American Aviation, Inc.

It is evident from the nature of the ion propulsion system that, if the mass of the exhaust gases is low, an ion-drive vehicle will accelerate very slowly. Thus, it would be impractical to use ion propulsion where we require short-period, high-acceleration flight, as from the surface of a planet. But in interplanetary space, powered operation could be continuous, with the Stuhlinger ship traveling from an earth-satellite orbit to a Mars-satellite orbit and back in about two years.

A similar vehicle is proposed under Project Snooper, by scientists at North American Aviation, Inc., which has an ion-propulsion study contract. Its two ion motors would discharge cesium vapor at nearly 125 miles per second, giving a thrust of one-third pound, or about 1/10,000 the acceleration of gravity at the earth's surface. Nevertheless, the acceleration would be 0.04 inch a second each second, so that after its first full day of operation with a continuous ion drive, this vehicle's speed would have increased by 200 miles an hour!

For this ship, molten cesium would be stored in a pressurized tank, heated to about 150° Fahrenheit by an electric blanket. The cesium would be vaporized at 1,500°, and flow through a sintered steel distributor to an incandescent tungsten grid of large surface area, where ionization would take place. Acceleration would occur as the ions passed through a direct-current potential difference of 27,500 volts, the cathode being a honeycomb structure with a uniform electrostatic field.

Nuclear Power. The use of nuclear energy in rockets may be considerably further from realization than is an ion propulsion system. Any practical type of atomic rocket engine that can be visualized today would require a working fluid heated by a nuclear reactor. This means that the energy and exhaust gas sources are different, rather than the same as in chemical systems.

However, the separation of energy sources gives a greater flexibility of operation, and the energy concentration can be much higher than with chemical propellants.

As was learned about 20 years ago, the elementary particles known as neutrons can cause splitting or fission of uranium atoms and other heavy elements. In the process energy is given off and new neutrons are released. In order to sustain the reaction, we must make sure that neutron births exceed the loss of neutrons due to their escape from the system or their capture by the material of which it is made.

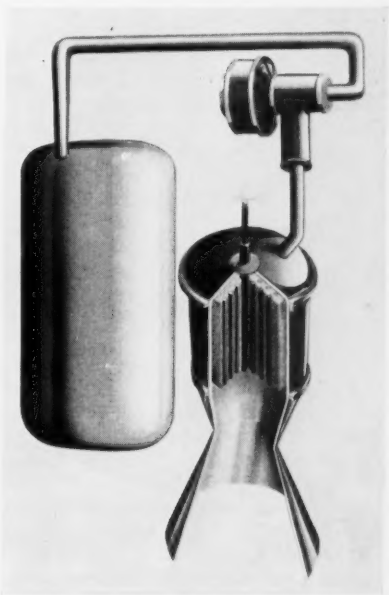
PROPELLANT PERFORMANCE

Propellant	*Specific Impulse*
Today's chemical propellants	200 - 250
Tomorrow's chemical propellants	250 - 350
Free radicals	400 - 1,000
Nuclear	400 - 3,000
Ion recombination	800 - 1,500
Ion acceleration	300,000

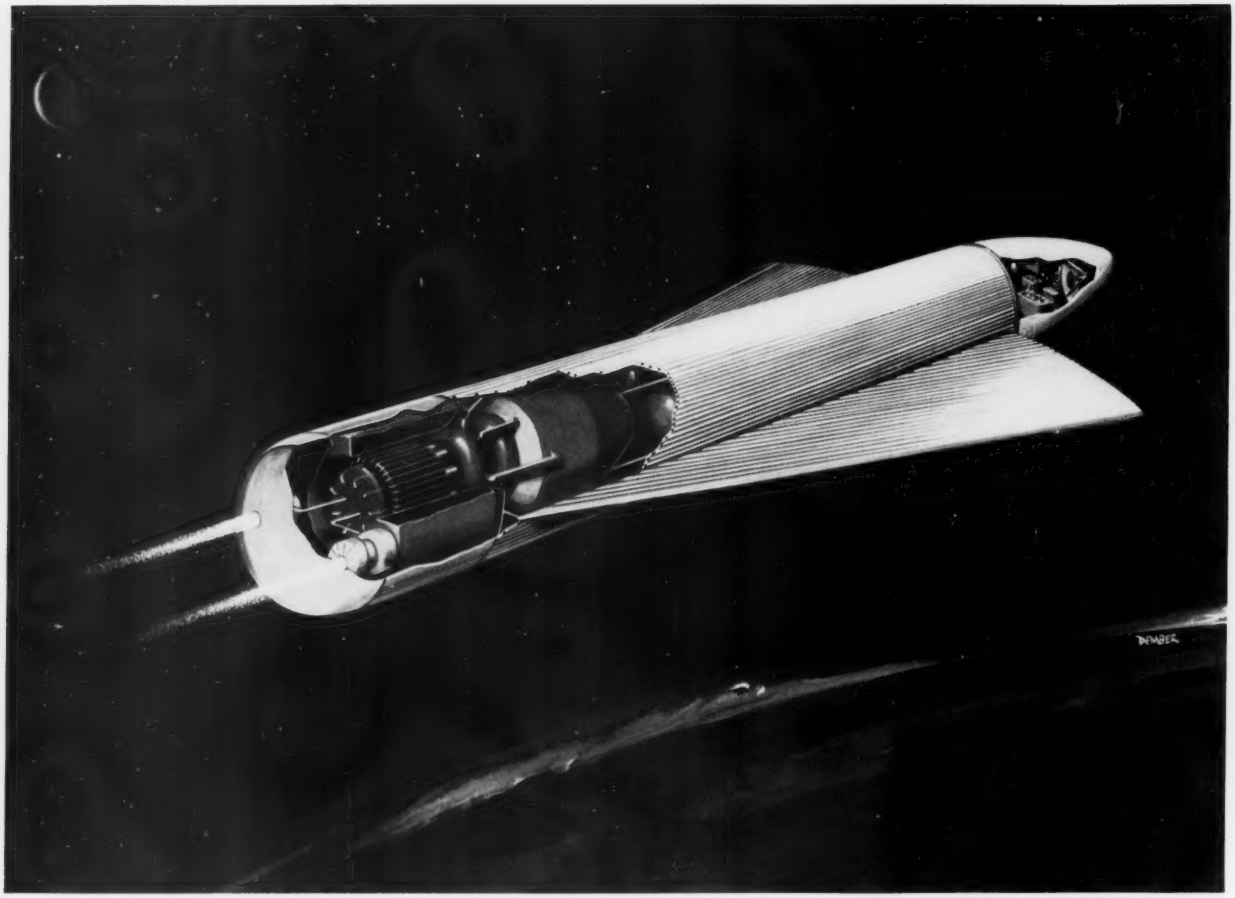
The nuclear process generates enormous heat, which must be carried off through a heat exchanger of large surface area. But while high temperatures are desirable in the nuclear engine, rocket chamber materials can withstand temperatures of only about 6,000° F. — above this value most materials become gaseous.

The heat from the reactor would be supplied to the working fluid or propellant. Likely candidates for the latter role include hydrogen, methane, and ammonia, which would be pumped through tubes within the reactor. High specific impulses would be reached. For example, if hydrogen could be used at a temperature of 8,000° F., a specific impulse of 1,000 pound-seconds per pound would result. Exhaust velocities would be high, up to 13,000 miles per hour for hydrogen. Future possibilities include utilizing the nuclear particles themselves as propellants.

Experiments dealing with thermonuclear processes are being carried out. These fusion reactions involve creation of a heavier element or isotope from the joining of two lighter isotopes. An example is the combining of hydrogen atoms in the hydrogen bomb, which yields far more energy than does fission of heavy atoms. To start fusion an extremely high temperature is needed, and the reaction must be strongly controlled in order that



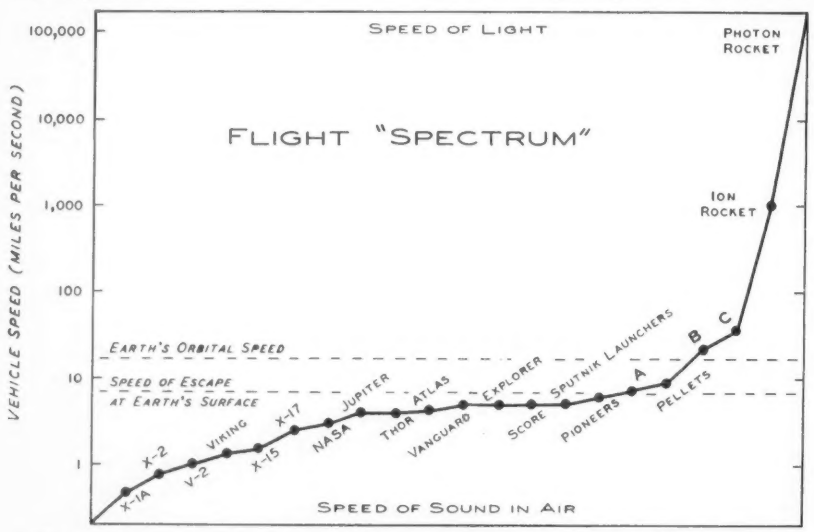
A schematic drawing of a proposed liquid-propulsion system with a nuclear reactor to heat the working fluid, which would flow from the tank at the left.



An artist's conception of an ion rocket in outer space. A nuclear reactor supplies power to ionize and accelerate particles which provide the thrust. Wing-shaped attachments radiate excess heat. North American Aviation picture.

the energy is not released in a brief, explosive burst. Eventually, however, a rocket motor run by thermonuclear processes may be practical.

Remoter Possibilities. Besides the chemical, ion, and nuclear propulsion systems we have been discussing, rocket engineers have been exploring other, less conventional means for powering flight into space.



The performances of various vehicles are compared, from one of the earliest supersonic test crafts (the Bell X-1A) to the photon rocket, which could theoretically approach the speed of light. The "pellets" of October 16, 1957, were described last month (page 201). Labels A, B, and C are for the Russian space probe of January 2, 1959, marking its velocity at burnout (A) and with respect to the sun at aphelion (B) and perihelion (C).

Krafft Ehricke has proposed that the radiant energy of the sun be utilized. He has imagined an eight-ton vehicle which, after it has reached interplanetary space, will be accompanied by two spherical reflectors, each of 128-foot diameter. These are to be inflated shells of thin polyethylene plastic, one hemisphere being metallized to concentrate the sun's rays at its center. They would heat liquid hydrogen, to provide hydrogen gas that would be piped to the exhaust nozzle. Only a low acceleration would be achieved, and the spherical shells would be vulnerable to meteorite puncture. Nevertheless, some variant on this idea, perhaps a huge "sail" of metal foil, may eventually be of practical value in astronautics.

Another scheme that has considerable theoretical interest is the photon rocket. In principle, if a sufficiently intense source of radiant energy could be maintained in the rocket, the recoil of the radiation from a highly reflecting mirror would impart a large thrust to the vehicle. The attractive point about this proposal is that the velocity of the photon exhaust would be the speed of light. However, at present the photon rocket is only a dream on a distant horizon.

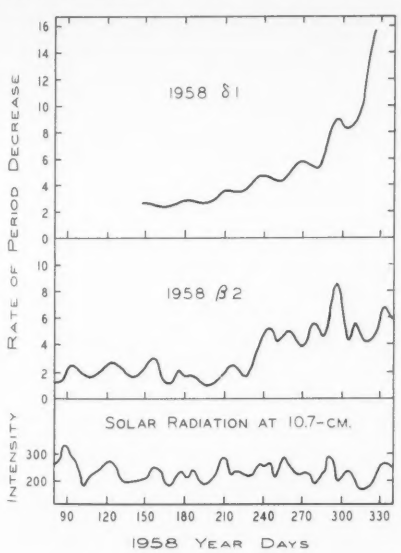
NEWS NOTES

FLUCTUATIONS IN PERIODS OF ARTIFICIAL SATELLITES

One of the most perplexing problems of artificial satellites has been the observed irregular or semiperiodic fluctuations of their periods, which cannot be explained on the basis of gravitational theory. Luigi G. Jacchia, Smithsonian Astrophysical Observatory, who first discovered these anomalies, now presents definite evidence that they can be explained by changing atmospheric structure — variations in the density of the highest regions of the atmosphere — caused by variable solar radiation.

As can be seen from the graph, the periods of satellites 1958β2 and 1958δ1 fluctuated in unison. There is evidence that 1958α, 1958γ, and 1958ε also had similar period changes. It seems evident, therefore, that the effect is a global one — a rhythmic pulsation of the atmosphere as a whole. The pulsation increases with height, because the oscillations are much greater for high-moving 1958β2 (the long-lived Vanguard 6-inch sphere).

The satellite curves correspond remarkably with that of 10.7-centimeter solar radio energy, but because this radiation penetrates the atmosphere without being absorbed it cannot cause the observed effects. High-energy radiation of much shorter wave lengths must be the agent, and the 10.7-cm. emission is just an index of its amount. We cannot observe the short-wave energy if it is all absorbed by the atmosphere.



These curves by L. G. Jacchia show that the acceleration of artificial satellites—caused by atmospheric resistance which shortens their periods of revolution—does not take place uniformly. The fluctuations seem correlated with the curve of 10.7-cm. solar radiation. The vertical scale units are 10^{-5} day per day for 1958δ1; 10^{-7} day per day for 1958β2; and 10^{-22} watt per square meter per cycle per second bandwidth for the 10.7-cm. solar radio flux.

The 10.7-cm. curve exhibits a distinct periodicity of about 27 days, equal to the average apparent period of rotation of the sun. The maxima in the curve seem to correspond to central passages of active sunspot regions, which are known to emit considerable short-wave radiation.

Superimposed on the effect described here, artificial satellite orbits have other fluctuations. For example, there is a noticeable dependency of the period on the angular distance of a satellite's perigee from the subsolar point, probably due to a difference in upper-air densities between the dark and bright hemispheres of the earth. Another effect is caused by the bulging of the atmosphere at the equator.

FORBIDDEN OXYGEN LINES IN METEOR SPECTRA

The auroral green line at 5577 angstroms, a forbidden line of neutral oxygen atoms, has been observed in the spectra of three meteors photographed at the Meanook Meteor Observatory, Alberta, Canada. In all cases this line was the first feature to appear in the spectrum as the meteor descended, disappearing before most of the other lines became observable. The red auroral lines of neutral oxygen were not observed.

Ian Halliday, Dominion Observatory, Ottawa, reports in the September, 1958, *Astrophysical Journal,* that the meteors included two of the August, 1956, Perseids, and one of the April, 1957, Lyrids. The two Perseid spectra were obtained within an hour of each other, and the oxygen line was stronger in them than in the Lyrid, although the latter was by far the brightest of the three meteors.

The observations of this line, which appeared at heights of about 60 miles, are counter to the expectations of some earlier investigators who have thought that forbidden lines would not occur in meteor radiation. As to why they have not been detected in other meteor spectra, Dr. Halliday suggests the 5577 line may be sensitive to certain upper-atmosphere conditions. He points out that all three spectra were obtained during periods of general solar activity but not during large disturbances.

EARLY VOLUMES OF "ASTROPHYSICAL JOURNAL" REPRINTED

Libraries and observatories have long found it difficult to obtain copies of the *Astrophysical Journal* of many years ago, as they have been out of print. Volumes 1-10, for the years 1895-99, have now been reprinted, and a reissue of Volumes 11-53 (1900-21) is in preparation. Inquiries should be addressed to the Johnson Reprint Corp., 111 Fifth Ave., New York 3, N. Y.

IN THE CURRENT JOURNALS

DYING STARS, by Jesse L. Greenstein, *Scientific American,* January, 1959. "The smallest white dwarf known has an estimated radius of only 2,800 miles, much smaller than the radius of the earth. This is close to the theoretical minimum for a star that has exhausted its hydrogen; the radius indicates a mass of 1.2 solar masses and a central density of 150 tons per cubic inch."

CHINESE ASTRONOMER DIES

Chang Yuin, a prominent Chinese astronomer and educator, died on October 27, 1958, at Kowloon, Hongkong, at the age of 63. From 1946 to 1949, when he became a political exile, he was president of the University of Canton and professor of astronomy there.

In addition to his extensive researches on short-period variable stars, he was the author of a widely used Chinese textbook on astronomy. During a visit to the United States in 1947-48, he worked at Harvard Observatory.

SHAPE OF THE EARTH

Studies of the orbital motion of the grapefruit-sized Vanguard satellite (1958β2), launched on March 17, 1958, show that the earth is slightly persimmon-shaped — stem end at the South Pole — rather than like a basketball. This result was reported at the annual meeting of the American Physical Society in January by Robert Jastrow, National Aeronautics and Space Administration.

The perigee point of this satellite's orbit swings completely around the earth in 82 days, thus causing the nearest approach to the earth to occur sometimes in the Southern Hemisphere, and at other times in the Northern. Observations show that the perigee height is greater in the former case than in the latter. This difference cannot be explained by atmospheric drag, or electrical or magnetic forces, but is probably due to a slight deviation of the earth's shape from an oblate spheroid.

The known flattening of the earth through the poles amounts to about 27 miles. As reported in the January 29th New York *Times,* the newly suggested shape involves superimposing on the known flattening a 50-foot rise in sea level at the North Pole, and a 50-foot lowering at the South Pole. Outside the polar caps, sea level is about 25 feet lower in the Northern Hemisphere and 25 feet higher in the Southern. These combined effects give the earth the shape of a persimmon with its broad portion in the Antarctic.

One implication of this result is that, to withstand the strains imposed by the bulges and depressed areas, the presumably molten material below the crust of the earth must be less elastic than presently assumed.

Amateur Astronomers

Amateur Convention To Tour Air Force Academy

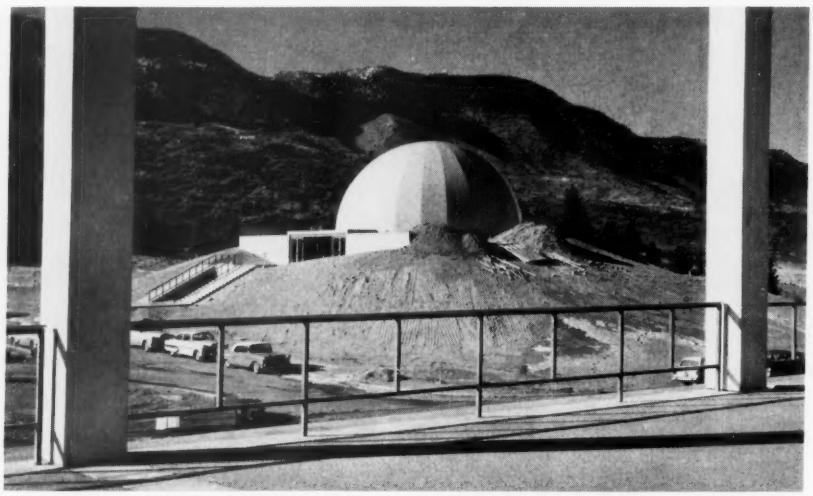
DURING the Nationwide Amateur Astronomers Convention this August 28-31 in Denver, Colorado, the most extensive of three planned field trips is scheduled for Saturday, August 29th. After lunch, chartered buses will make the 60-mile trip to the Air Force Academy in Colorado Springs, newest of the military service academies.

A guided tour of the campus will include a visit to the planetarium (see front-cover picture), which has been in operation since January. The 50-foot dome houses a Spitz Model B projector, similar to the one at the Longway Planetarium in Flint, Michigan (Sky and Telescope, August, 1958, page 500). As in that installation, the 1,200-pound instrument is supported in the middle of the chamber by steel aircraft cables, which seem to disappear when the lights are dimmed.

The planetarium was acquired by the Air Force to aid in teaching celestial navigation to the cadets. It is also used to supplement introductory courses in astronomy and space travel. Showings are scheduled for the public periodically and to special groups by arrangement.

Specially designed upholstered benches accommodate 288 persons. There is an elaborate sound system, and cove lighting permits the use of three individual sky colors or any desired blend of them. Three auxiliary projection booths are located around the periphery of the main chamber to provide for showing motion pictures, lantern slides, and for special effects. Major Floyd C. Ethridge is the planetarium director.

From the Air Force Academy, the bus caravan will go to the Garden of the Gods, a natural park area near Colorado Springs which is famous for its huge red sandstone formations that lie virtually in the shadow of 14,109-foot Pike's Peak. There the Junior Chamber of Commerce of Colorado Springs will provide a chuck-wagon dinner followed by an hour's entertainment with western music.



Pillars on the first level of the Air Force Academy's administration building frame the new planetarium against the Rampart mountain range. The planetarium structure is circular, 71 feet in diameter, the entrance facing southward. It was dedicated on January 26th, and that evening the entire sophomore class attended a lecture on celestial navigation. Free public demonstrations are scheduled four times a week. U. S. Air Force photograph.

The cost of this field trip, and of the others to Boulder and Climax, Colorado, has not been set, but they all will be relatively inexpensive. Convention delegates will have the choice of a complete package of field-trip tickets, or of individual field trips. Each tour will be made by chartered bus only.

Registrations for the convention should be made now. Until May 1st, the fee is $2.00 per person and $3.00 for a family; after that date, $2.50 each person and $3.50 per family. Remittances will be accepted by Ned Onstott, 2421 Second Ave., Pueblo, Colo. Room reservations at the University of Denver may also be made with him; details were printed on page 142 of the January issue.

KEN STEINMETZ
1680 W. Hoye Place
Denver 23, Colo.

Amateurs attending the Denver convention will be guests at a chuck-wagon dinner in the shadow of the towering monoliths of Colorado's Garden of the Gods. Colorado Springs Chamber of Commerce photograph.

NORTH-CENTRAL CONVENTION

The 1959 convention of the North-Central Region of the Astronomical League will be held at the Argonne National Laboratory, Lemont, Illinois, on Saturday, May 23rd. The Argonne Astronomy Club is the host society for the convention.

Meetings will be in the chemistry building auditorium, where ample space is available in the lobby for exhibits. The registration fee, $1.00 until May 1st, may be sent to H. F. DaBoll, Box 299, Lemont, Ill. Because of restrictions at the laboratory, it is requested that any aliens planning to attend register well in advance and give information concerning their citizenship.

SOUTHEAST CONVENTION

The George Washington Hotel in Jacksonville, Florida, will be the site for the Southeast Regional meeting of the Astronomical League, May 8-10, with the Jacksonville Astronomy Club as host. All sessions, including the banquet on the 9th, will be held there.

For the entertainment of those attending, the hotel's 72-foot yacht has been reserved for ocean cruises on both Friday and Saturday. Ernest L. Rowland, 345 E. Forsyth St., Jacksonville, Fla., will accept registrations.

THIS MONTH'S MEETINGS

Baltimore, Md.: Baltimore Astronomical Society, 8 p.m., Enoch Pratt Library. March 16, Gen. Don Flickinger, Air Force Bioastronautics Section, "Human Factors in Space Travel."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. March 6, Dr. Lawrence Aller, University of Michigan Observatory, "Compositions of the Stars."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Health Museum Planetarium. March 23, R. L. Hupp, "Time and Eternity."

Lemont, Ill.: Argonne Astronomy Club, 8 p.m., chemistry building, Argonne National Laboratory. March 20, William Sickman, Jr., "A Planet's Atmosphere."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. March 4, Dr. Malcolm P. Savedoff, University of Rochester, "Gamma-Ray Astronomy."

New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly building, New York University. March 20, Dr. Sergei Gaposchkin, Harvard Observatory, "Circumnavigation of the Globe in Quest of Astronomical Adventure."

Also 2 p.m., main building, New York University. March 21, Kenneth Weitzenhoffer, "Observing Comets."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. March 13, Charles A. Federer, Jr., Harvard Observatory, "Some Western Observatories."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. March 7, Dr. Harlow Shapley, Harvard Observatory, "Highlights of the Past 50 Years in Astronomy."

DUBUQUE, IOWA

A group of 25 amateurs set up the Dubuque Astronomical Society last October. Telescopes owned by members include two 12½-inch Newtonians. Under construction are three Cassegrainians ranging in size to 16 inches, as well as several Newtonian reflectors. Officers are Edward Plamondon, president; Edward Bush, vice-president; and Martin Miller, treasurer. The secretary is Howard Klauer, 1795 Adair, Dubuque, Iowa.

VIENNA, WEST VIRGINIA

Of the dozen members in the Vienna Astronomical Society, six are juniors. The president is William T. Dixon, 3501 10th Ave., Vienna, W. Va.

MANCHESTER, NEW HAMPSHIRE

There are six members in the newly formed Manchester Astronomical Society. Interested persons may obtain further details from Richard E. Durette, 8 Keene St., Bedford, N. H.

CONTACTING NATIONAL ORGANIZATIONS

Many amateurs are interested in affiliating with a national organization. Information may be obtained from the officers listed here.

American Association of Variable Star Observers. Mrs. Margaret W. Mayall, Director, AAVSO, 4 Brattle St., Cambridge 38, Mass.

American Meteor Society. Charles P. Olivier, President, American Meteor Society, 521 N. Wynnewood Ave., Narberth, Pa.

Association of Lunar and Planetary Observers. Walter H. Haas, Director, ALPO, 1835 Evans Place, Las Cruces, N. M.

Astronomical League. Mrs. Wilma A. Cherup, Executive Secretary, Astronomical League, 4 Klopfer St., Pittsburgh 9, Pa.

Western Amateur Astronomers. Walter J. Krumm, Chairman, WAA, 10628 Larry Way, Cupertino, Calif.

INTERNATIONAL LUNAR SOCIETY

James Q. Gant, Jr., of Washington, D. C., has been elected president of the International Lunar Society for the years 1959-60. He succeeds H. P. Wilkins, who founded the organization in 1956 to correlate the work of lunar observers in different countries. Other officers are: vice-presidents, G. D. Roth (Germany) and A. Fresa (Italy); general secretary, F. D. Brewin (England); permanent secretary, A. Paluzie-Borrell (Spain); and director of research, Dr. Wilkins. P. A. Moore (England) is the new editor of the *Journal* of the International Lunar Society.

Dr. Gant, who is a dermatologist by day, has been observing the moon since 1920. During recent years he has been using a 12-inch Cassegrainian reflector, mounted in a two-story observatory with slide-off roof, at Boyds, Maryland.

Persons interested in joining the society should write to Professor Paluzie-Borrell, Diputacion 377, Barcelona, Spain.

TORONTO, CANADA

During 1958, the telescope makers' group of the Royal Astronomical Society of Canada held 21 working meetings with an average attendance of about 30. Twenty-eight telescopes were completed: one 12½-inch Cassegrainian, one 10-inch Newtonian, two 8-inch, and 24 6-inch instruments. At present we have 60 members grinding telescope mirrors.

From April to October we held a star party at the David Dunlap Observatory each Saturday night. Our best attendance was one night last August, when large crowds viewed Sputnik III and its carrier rocket through our telescopes. We also had six or eight instruments in use almost every night during the Toronto exhibition, and throughout the summer in the city parks.

JESSE KETCHUM
Royal Astronomical Society of Canada
252 College St.
Toronto 2B, Canada

QUESTIONS... FROM THE S+T MAILBAG

Q. What is a billion?

A. In the United States it is a thousand million (1,000,000,000 or 10^9), but in England and most other countries the word billion is used for a million million (10^{12}). In SKY AND TELESCOPE this term always means 10^9, while 10^{12} is a trillion.

Q. What are the focal ratio and focal length of the 200-inch mirror of the Hale telescope?

A. The focal ratio is f/3.3, giving a prime focal length of 55 feet.

Q. What are the distances from Mars to its two satellites?

A. The distance from Mars to Phobos is 5,800 miles, center to center, so this larger satellite revolves 3,700 miles above the planet's surface. Deimos is 14,600 miles from the planet's center.

Q. Is the dome of Palomar Observatory's 200-inch telescope heated when it is being used at night in winter?

A. No. The best observing conditions are obtained when the temperature inside an observatory dome is the same as outside, for the motion of unevenly heated air has a bad effect on star images.

Q. What is the current status of the natural bridge on the moon supposedly discovered by John J. O'Neill in 1953?

A. Many experienced lunar observers have failed to find any trace of it, and it is generally agreed that the original report of a bridge must have been erroneous.

Q. Can either of the inferior planets, Mercury or Venus, reach a position of quadrature – 90 degrees from the sun in the sky?

A. No. Only superior planets, with orbits larger than the earth's, can be seen in quadrature.

Q. How many constellations are there in the sky?

A. The International Astronomical Union recognizes 88 constellations; their boundaries were specified in 1930.

Q. What units do the symbols °, ′, and ″ stand for in Celestial Calendar, where they are used to specify the sizes of various astronomical bodies?

A. These are the angular units of measure: degree (°), minute (′), and second (″), and indicate apparent size. There are 360° in a full circle around the sky, 60′ in a degree, and 60″ in a minute. The moon and the sun have apparent diameters of about ½° or 30′, while Mars at its nearest is 25″ (a little less than ½′) in diameter. W. E. S.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 101st meeting of the American Astronomical Society at Gainesville, Florida, in December, 1958. Complete abstracts will appear in the Astronomical Journal.

Martian Vegetation

The best evidence yet for the existence of plant life on Mars was reported by William M. Sinton, Lowell Observatory, from an infrared study made last fall with the 200-inch telescope on Palomar Mountain.

The seasonal darkening and fading of the dusky regions of Mars have long suggested the presence of vegetation. Photographs of the planet have been taken for more than half a century by E. C. Slipher of Lowell Observatory, and show that every Martian spring and summer a wave of darkening spreads from polar latitudes toward the equator. Nonsystematic changes also occur: areas that for many years had been orange desert have become dark, and a few dark regions have changed to bright ones.

To test for the presence of plant life, several astronomers have examined the spectrum of Mars for the characteristic bands of chlorophyll. The failure to find such bands, however, does not rule out the presence of vegetation, as the Martian plants might resemble lichens, which do not contain chlorophyll.

Dr. Sinton applied a new criterion. All large organic molecules can absorb infrared light of about 3.5 microns wave length, corresponding to the resonance frequency of the bonds between their carbon and hydrogen atoms. During the 1956 opposition of Mars, he sought to detect this spectrum feature, using the 61-inch reflector of Harvard Observatory, with promising but not wholly conclusive results (Sky and Telescope, April, 1957, page 275).

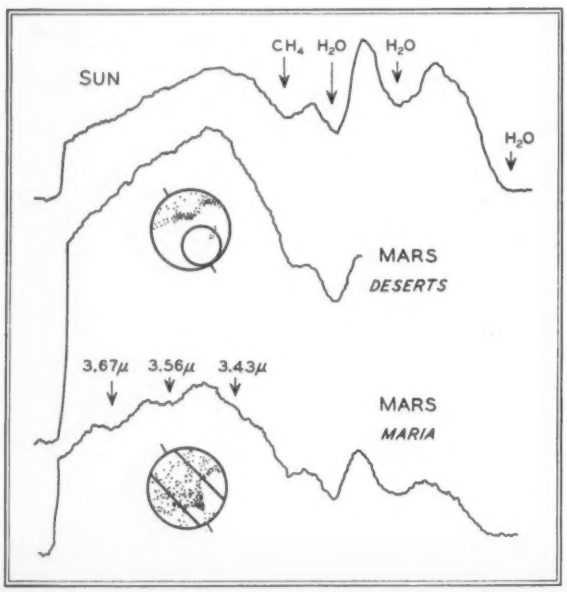
At Mars' 1958 opposition, Dr. Sinton repeated this test with improved detectors mounted at the coude focus of the 200-inch telescope, where the planet's image was about half an inch in diameter. The sensitivity of his equipment was 10 times better than before, and with the large image size allowed him to study portions of the planet's surface individually instead of just its disk as a whole. His observations were made in the morning twilight hours, after other observations with the Hale telescope requiring a completely dark sky had ended for the night.

Not only was the presence of the infrared absorption definitely confirmed, but Dr. Sinton established that it occurred in dark regions (Syrtis Major, Pandorae Fretum, Mare Sirenum, and Mare Cimmerium) and was absent or weak in bright areas (Arabia, Amazonis).

In terrestrial plants, the absorption feature is double, at wave lengths of about 3.41 and 3.51 microns. The Mars observations, however, showed three absorptions, at 3.43, 3.56, and 3.67 microns. The presence of the third band may indicate a significant difference in the type of molecules present on the two planets, Dr. Sinton suggests. Nevertheless, the Martian absorptions are so close to 3.5 microns that they are definitely due to organic molecules.

The 1956 observations, in which radiation from the entire disk was used, could have been explained by the presence of organic molecules, such as methane, in the atmosphere of Mars. This interpretation can now be ruled out, as the nonuniform distribution of the absorption indicates that the molecules are on the planet's surface.

It is plausible to assume that wherever the Martian surface is dark these bands occur, including the major deep-toned regions that have developed in the course of a few years. If this is true, Dr. Sinton concludes, organic molecules are produced over large areas within short time spans, and the growth of vegetation seems the simplest explanation for the appearance of this organic matter.



Infrared spectrum tracings secured by William M. Sinton with the 200-inch telescope. In the top curve, water and methane in the earth's atmosphere have introduced deep telluric absorptions into the spectrum of direct sunlight. The middle curve is for the Martian desert region of Amazonis, indicated by the circle on the inset sketch. In the bottom curve, for a Martian strip including Syrtis Major and other dark areas, three small but distinct dips occur at the wave lengths marked. These may be produced by organic molecules on Mars' surface. Lowell Observatory chart.

Astronomical Uses for Artificial Satellites

"Many years ago Henry Norris Russell remarked that all good astronomers go to the moon after they die so that they can see the heavens freed from the complications produced by the earth's atmosphere." Thus did Lawrence H. Aller begin his summary of the research applications of artificial satellites in astronomy, as distinguished from their more publicized geophysical uses.

Some realization of the astronomers' desire to be free of the atmosphere has already been achieved with artificial satellites, and Dr. Aller outlined anticipated progress in the next few years, when instrument payloads of space vehicles will have increased to several thousand pounds. The University of Michigan astronomer spoke as the representative of Leo Goldberg, chairman of the astronomy committee of the National Academy of Sciences' Space Science Board.

Already contemplated are the sending of 50-pound probes to the vicinities of Mars and Venus, and the landing of a 250-pound payload on the moon. Probably 10 such initial explorations could be carried out in the next two years. Later plans include space stations and, eventually, a lunar observatory. In the very earliest experiments, however, weight limitations will impose severe restrictions.

The Space Science Board considers each experiment as divided into five phases. First come feasibility studies to ascertain whether it can be performed within the weight and power-supply limitations. Next a model of the critical components is tested. In the third phase, a flight-prototype model having all necessary equipment is developed. The fourth phase is the flight itself, including checkout, launching, and telemetering of the observations back to the earth. The final operation involves reduction and analysis of the data.

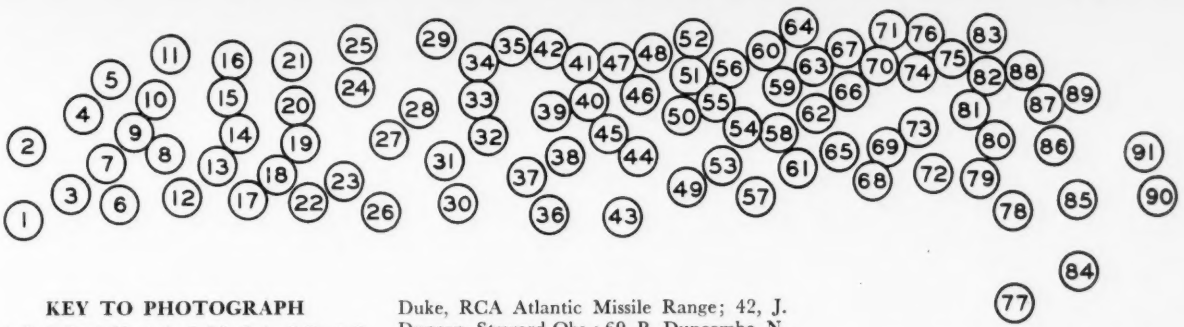
Among the experiments proposed by the Space Science Board, several offer possibilities of major advances in astronomy, and will be described briefly.

General Theory of Relativity. Of the three experimental checks on the theory of general relativity — the advance of the perihelion of Mercury, the deflection of light rays near the sun, and the red shifts of stellar spectral lines in a gravitational field — only the first is reasonably satisfactory. The third effect has never been definitely observed, but with the aid of satellites might be firmly established.

The rates at which two identical atomic clocks keep time, if they are placed at points with unequal gravitational potentials, should disagree by an amount equal to the potential difference divided by the square of the velocity of light. If an atomic clock is flown in a suitable satellite, calculations show that its rate should diverge from that of a terrestrial counterpart by several units in 10 billion (10^{10}). The relative motions of the two clocks will superimpose differences of about the same size, but their amount can be allowed for. Thus, the major practical problem involves only a choice of a frequency standard.

At Boulder, Colorado, National Bureau

The 101st meeting of the American Astronomical Society, December 29, 1958. University of Florida photograph.



KEY TO PHOTOGRAPH

1 F, 2 D, 3 H, 4 A, 5 M, 6 A, 7 R, 8 S, 9 B, 10 B, 11 H, 12 R, 13 D, 14 S, 15 F, 16 D, 17 S, 18 M, 19 G, 20 M, 21 D, 22 H, 23 M, 24 R, 25 W, 26 G, 27 O, 28 H, 29 S, 30 E.

31 P, 32 S, 33 G, 34 S, 35 C, 36 V, 37 S, 38 C, 39 S, 40 K, 41 W, 42 D, 43 E, 44 C, 45 C, 46 S, 47 W, 48 C, 49 N, 50 B, 51 S, 52 S, 53 S, 54 G, 55 W, 56 R, 57 H, 59 V, 60 O.

61 I, 62 S, 63 H, 64 F, 65 C, 66 M, 67 F, 68 M, 69 D, 70 W, 71 B, 72 M, 73 V, 74 A, 75 T, 76 B, 77 F, 78 F, 79 F, 80 G, 81 W, 82 S, 83 S, 84 F, 85 H, 86 W, 87 D, 88 E, 89 M, 90 W, 91 S.

ALPHABETICAL LIST

4, H. Abt, Yerkes Obs.; 58, J. Allen, S. Florida; 6, L. Aller, Michigan; 74, D. Andrews, Dominion Astrophysical Obs.

71, J. Baker, H; 10, T. Bartlett, Colorado Springs, Colo.; 9, D. Billings, High Altitude Obs.; 76, R. Bless, Wisconsin; 50, N. Bobrovnikoff, Ohio State.

35, W. Calder, Agnes Scott; 44, G. Clemence, N; 48, G. Conant, H; 65, R. Cowan, F; 45, A. Cox, LASL; 38, Mrs. A. Cox.

21, M. Davis, Y; 13, R. Davis, SA; 87, A. Deutsch, MWP; 16, J. Douglas, Y; 2, D. Duke, RCA Atlantic Missile Range; 42, J. Duncan, Steward Obs.; 69, R. Duncombe, N.

88, S. Edelson, NRL; 30, F. Edmondson, I; 43, R. Emmons, Goodyear Aircraft Corp.

15, C. Federer, H; 64, G. Field, P; 67, W. Ford, Carnegie Inst. of Washington; 1, K. Franklin, American Mus.-Hayden Planetarium; 79, Mrs. K. Franklin; 77, Miss C. Franklin; 78, Miss J. Franklin; 84, Miss K. Franklin.

19, B. Garfinkel, Ballistic Res. Lab.; 80, C. Gasteyer, We; 26, H. Grosch, Int'l. Business Machines; 33, Miss I. Gulledge, NRL; 54, D. Guthrie, Catawba.

11, I. Halliday, Dominion Obs.; 57, G. Hawkins, H; 85, Mrs. G. Hawkins; 63, C. Hemenway, Dudley Obs.; 28, K. Henize, SA; 3, G. Herzberg, Nat'l. Res. Council of Canada; 22, J. Hynek, SA.

61, J. Irwin, I.

40, G. Keller, Nat'l. Sci. Foundation.

68, Mrs. A. Massevitch, U. S. S. R. Academy of Sciences; 5, S. Matsushima, Florida State; 20, C. Mayer, NRL; 23, P. Merrill, MWP; 18, Mrs. P. Merrill; 89, Mrs. B. Morrison, N; 66, D. Morton, P; 72, G. Mulders, Off. of Naval Res.

49, G. Nielson, SA.

27, G. Omer, F; 60, V. Osvalds, Virginia.

31, T. Page, We.

7, E. Rabe, Cincinnati; 56, Miss A. Risley, Randolph-Macon; 24, F. Roach, NBS; 12, L. Roberts, F.

14, S. Schwartz, Nevada; 8, W. Sinton, Lo; 91, B. Sitterly, American Univ.; 53, Mrs. C. Sitterly, NBS; 37, A. Skumanich, LASL; 62, E. Slipher, Lo; 29, C. Smiley, Brown; 34, Mrs. C. Smiley; 83, A. Smith, F; 17, H. Smith, Y; 46, C. Stearns, We; 32, T. Sterne, SA; 51, S. Stone, LASL; 39, N. Storer, Kansas; 82, R. Sturm, Reed Instr. Co.; 52, R. Southworth, H.

75, S. Thorndike, Alma.

59, S. van den Bergh, David Dunlap Obs.; 73, G. van Herk, N; 36, A. Vyssotsky, Winter Park, Fla.

81, M. Walker, Lick Obs.; 90, G. Wares, A. F. Cambridge Res. Center; 70, E. Weston, Amherst; 47, M. White, NBS; 41, G. Whittaker, N; 25, R. Wilson, Nat'l. Aeronautics and Space Adm.; 86, F. Wood, Pennsylvania; 55, E. Woolard, N.

F, Florida; H, Harvard; I, Indiana; LASL, Los Alamos Scientific Laboratory; Lo, Lowell; MWP, Mount Wilson-Palomar; N, Naval Observatory; NBS, National Bureau of Standards; NRL, Naval Research Laboratory; P, Princeton; SA, Smithsonian Astrophysical; We, Wesleyan; Y, Yale.

of Standards scientists have proposed using an ammonia maser, which has a frequency stability of one part in 10^{11}. P. Bender, of the Bureau of Standards in Washington, D. C., suggested the 6834.68-megacycle radiation of rubidium-87 vapor as the frequency standard, while J. R. Zacharias, Massachusetts Institute of Technology, recommended cesium atomic-beam frequency standards, which are commercially available under the trade name Atomichron, and can be used as atomic clocks.

In such a case, the frequency standard is used as the "pendulum" or escapement of the clock. The difficult task, in practice, is to compress the clock in both size and weight to fit into a satellite and to make sure that it can survive the rigors of the launching.

For orbits of a suitable size, the relativistic effect would amount to about three parts in 10^{10}, or 30 microseconds per day. Since the transmission time for signals from the satellite to the ground may be uncertain by about five microseconds, a clock with an accuracy of one part in 10^{11} would have to run over a period of several weeks in order to measure the gravitational relativistic effects accurately.

Gravitational and Atomic Time. G. M. Clemence, U. S. Naval Observatory, and Lyman Spitzer, Jr., Princeton University Observatory, have independently proposed an experiment to check on a possible difference between gravitational and atomic time scales. According to certain theories, the difference in frequency between an atomic and a gravitational clock is t/T, where t is the time elapsed since the two clocks were adjusted at the same frequency and T is the age of the universe. If the latter is taken as five billion (5×10^9) years, we would expect a gain of one clock on the other of two parts in 10^{10} per year.

The moon is the most favorable natural gravitational clock, as time may be deduced with high accuracy from measurements of the moon's position in the sky. But its orbital motion is slow, and a rapidly moving artificial satellite would be an even more accurate gravitational timekeeper, taking perhaps one-tenth as long as the moon to give a satisfactory result.

In consultation with Princeton University Observatory astronomers, Dr. Clemence has formulated the following specifications for such a satellite's orbit: a distance from the center of the earth of at least 16,000 miles to minimize atmospheric drag, yet not more than 24,000 miles to keep lunar perturbations small; an orbital eccentricity of less than 0.05 if possible; and an orbital inclination to the equator of about 40 degrees for ease in tracking and to avoid certain computational difficulties. The satellite is to be spherical with as small a cross-section as possible; it may carry a flashing light to facilitate observations. Finally, since atmospheric drag even at such great heights is not negligible, two satellites would be needed to give a measure of the effect of drag. Launched from the final stage of the same vehicle, these would be identical in every respect except for a weight placed in the center of one to make it 10 times as massive as the other.

In theory, these satellites should permit the determination of gravitational time with a precision of one part in 10 thousand million (10^{10}) in about two months. Actually, Dr. Aller pointed out, the experiment should be run for about two years. For lunar observations to give the same result, up to 20 years would be required.

Astrophysical Problems. The possibility of exploring the far-ultraviolet region of the spectra of the sun, stars, and nebulae is very inviting to the astrophysicist. Heretofore, our information has been obtained slowly and laboriously by means of high-altitude rockets. But these have given us only momentary snapshots, for example of the solar corona and chromosphere, whereas a continuous patrol is needed for a thorough understanding of their phenomena.

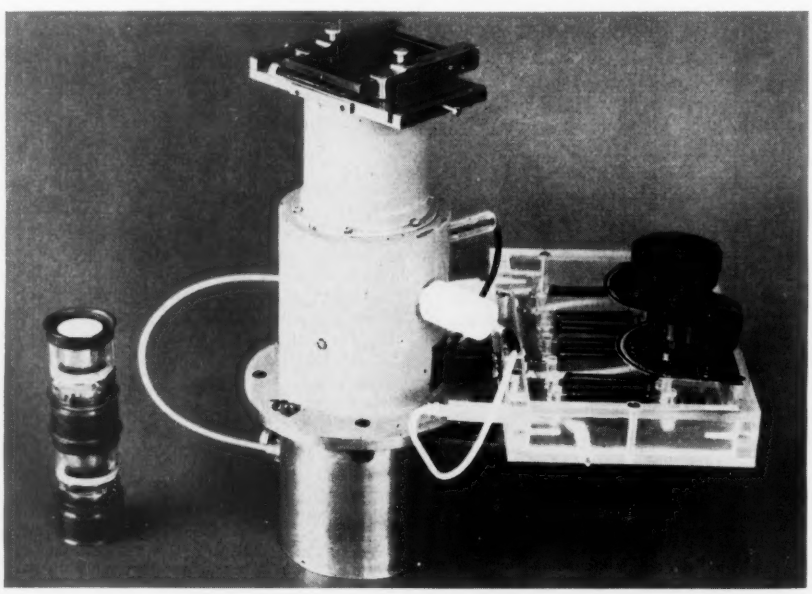
One of the most perplexing problems in solar physics concerns the structure of the upper chromosphere at the interface between the chromosphere and the corona. Most workers have attempted to explain either the optical or radio observations, rarely both, with results that contradict one another as to the temperature and density variations in the chromosphere. Knowledge of the detailed solar spectrum from 1500 angstroms down to X-rays would be of inestimable value in constructing a model for the solar chromosphere.

Other solar-system observations that can best be made from very high satellites are of the outer corona and zodiacal light, the long-wave end of the dynamic spectrum of solar radio bursts, and also radio bursts from Jupiter.

Tracking of stars, planets, or nebulae from a satellite requires special apparatus and a payload of a thousand pounds or more. Dr. Aller said that studies of individual faint stars and nebulae will probably require putting a man in space, as he doubts that a foolproof tracking mechanism can be devised for these elusive objects in the difficult observing conditions of outer space.

Already the first observations of the far-ultraviolet spectra of stars have been made with rockets by Naval Research Laboratory scientists. Measurements of the energy distribution in stellar spectra at very short wave lengths will provide a valuable check on theories of stellar atmospheres. The results from current rocket work are difficult to interpret, and much further effort is needed.

For instance, the star Spica, for which the line spectrum suggests an excitation temperature of 28,000 degrees, should be about 30 times brighter than it is observed to be in the region of 1300 angstroms, as measured by photon counters carried aloft in rockets. At the same time, a large nebulosity has been observed around Spica at far-ultraviolet wave lengths, yet in this part of the sky there is no visible nebulosity at all. Speculation on the origin of this radiation must be held in abeyance until its spectrum has been observed.



This 15-pound mounting is used to attach an RCA cascaded image converter (left) to a telescope, for the observations described on the facing page. As here oriented, light enters from the bottom, passing through the converter and an f/0.7 projection lens to the photographic plate. Lowell Observatory photograph.

Cascaded Image Converters

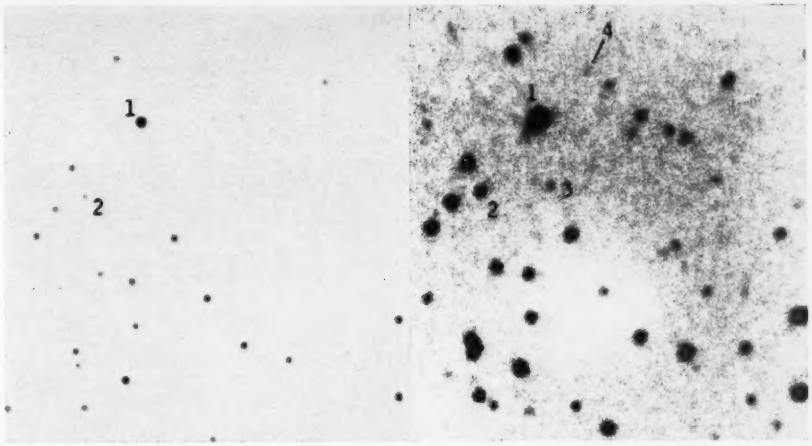
A significant advance in the application of electronic equipment to astronomical observations has been made by means of an RCA image converter that requires no auxiliary vacuum equipment. It has been used on telescopes in Flagstaff, Arizona, to obtain photographs of star fields and Mars. The experiments have been carried on by M. A. Tuve and W. K. Ford, Jr., Carnegie Institution of Washington; John S. Hall, Lowell Observatory; and W. A. Baum, Mount Wilson and Palomar Observatories.

They used a cascaded image converter, which receives an optical image at one end, intensifies it internally, and displays it at the other end where it can be photographed. In the present design there are two stages. Photons falling on a multialkali photoemissive cathode liberate electrons which are focused by an electrostatic lens onto an intensifying membrane. The latter is situated in the center of the tube, and consists of a thin film of glass coated on one side with a P11 phosphor screen. The other side carries photocathode material like that at the front of the tube. Electrons released from it are focused by a second electrostatic lens to another P11 phosphor screen at the output end of the tube.

In effect, the tube consists of a tandem arrangement of two simple image converters. As seen in the picture (facing page), the tube is about two inches in diameter and six inches long. It fits into a cylindrical housing that is attached to the eye end of the telescope; this housing also carries the photographic plateholder. The plastic box with two black knobs contains voltage dividers for controlling the electrostatic focusing voltages. The only auxiliary equipment required is a commercially available power supply.

With the U. S. Naval Observatory's 40-inch reflector, in an exposure time of only two minutes, the cascaded image converter reached the 18th magnitude, whereas direct photographs of the same duration showed only magnitude 16.5. The light gain of the converter system is actually considerably greater than the four times indicated by these results. The phosphor screen, however, has inherent imperfections and graininess, impressing a mottled pattern on the sky background which tends to limit the threshold magnitude of the converter. On long exposures these effects completely overpower the gain of the system.

Converters of this type were also used on the 24-inch refractor of Lowell Observatory in an effort to shorten the exposure time for photography of Mars and hence reduce the smearing effects of atmospheric seeing. Images of Mars were successfully obtained in 1/300 second (a tenth of the usual exposure time), but phosphor graininess has so far prevented any improvement over direct photographs of the planet.



Compare the unaided direct photograph (left) with an intensified picture (right) taken through the cascaded image converter. Both were two-minute exposures with the U. S. Naval Observatory's 40-inch reflector. The mottled sky background and nonuniform sensitivity in the right-hand picture are characteristic of the present converter tubes. Approximate photovisual magnitudes of the numbered stars are 12.5, 15.7, 16.9, and 18.0, respectively. This portion of the galactic star cluster NGC 1883 covers an area of 4.4 by 5.6 millimeters on the original plates. Photograph courtesy Lowell Observatory.

Cascaded image converters are promising as far simpler devices than some other existing astronomical image intensifiers. At present the main shortcomings of the RCA equipment are: nonuniformity and graininess of the phosphor screen, small diameter of the useful field, less than $\frac{1}{4}$ inch, and insufficient gain to utilize fully the quantum efficiency advantage of a photocathode over a photographic emulsion. Further work is in progress.

Abundance Differences Among Supergiants

Very luminous stars of spectral type *F* show a marked concentration to the spiral arms of our galaxy. This is consistent with the belief that they are very young stars that have not had time to move far from the interstellar clouds in which they were formed. Furthermore, the compositions of these young stars should still be the same as that of their original nebulae.

There are at least two *F* supergiants that are far from the spiral arms and about 3,600 and 8,500 light-years above the central plane of the galaxy. These stars are 89 Herculis and HD 161796, in galactic latitudes $+22°$ and $+30°$, respectively. At Yerkes Observatory, Helmut A. Abt has investigated the abundances of metals in their spectra, to determine whether or not they resemble those of *F* supergiants in the spiral arms.

Two similar stars in the galactic plane, Phi Cassiopeiae and Iota[1] Scorpii were used as controls, and spectra of all four objects were obtained. A detailed analysis showed a marked deficiency of metals in the high-latitude stars. Scandium, titanium, vanadium, and nickel are underabundant by factors of two to five compared to chromium and iron, while some rare earths are deficient by factors of four to 15.

If 89 Herculis and HD 161796 were formed in the galactic plane, they must have left it with rather high velocities (more than 150 kilometers per second for HD 161796) to arrive at their present locations high above the galaxy in their estimated lifetimes of eight million years. Dr. Abt feels that they were probably formed in interstellar clouds more than 8,000 light-years from the sun, either in or above the galactic plane, and that the observed stellar abundances reflect the actual abundances in the clouds at this distance.

CORRECTION AND ADDITION

Professor L. Binnendijk, University of Pennsylvania, has called attention to the fact that, in the first two lines on page 19 of my November, 1958, article, we should read: ". . . only 2/100 of a spectral class and ± 0.2 to ± 0.3 in absolute magnitude. . . ."

Concerning my article in September (page 548), Professor P. G. Kulikovsky, of the University of Moscow, has written me that the method of finding the line of nodes of the orbit of a visual binary attributed to Stewart and Henroteau had previously been developed by the Russian astronomer B. K. Mlodzeevsky. Professor Kulikovsky called attention to the work of the latter astronomer in the Russian *Astronomical Journal* in 1949.

OTTO STRUVE
Leuschner Observatory

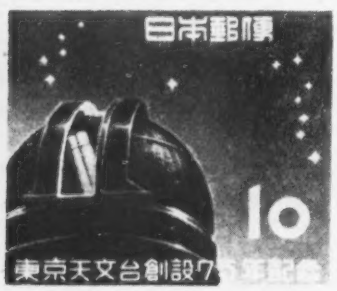
CORRECTION

On page 66 of the December, 1958, issue, three lunar craters in the key chart are misidentified. The names Azophi, Abenezra, and Geber should be Sisebuto, Azophi, and Abenezra, respectively. This was pointed out by Carlos E. Rost, Santurce, Puerto Rico.

Some Astronomical Stamps—III

ALPHONSE P. MAYERNIK

In 1958 Haiti issued this 50-centime green and red-brown pictorial depicting the enormous radio telescope at Jodrell Bank, England. At present, this instrument has by far the largest steerable parabolic antenna in the world, with a diameter of 250 feet.



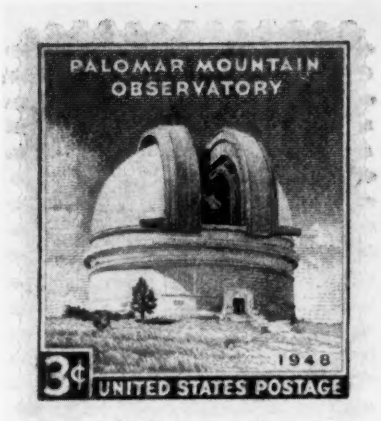
Against a background of Cassiopeia and the Big Dipper, a large refractor is visible through the slit of the dome on this 10-yen gray-blue Japanese stamp of 1953, marking the 75th year of the Tokyo Astronomical Observatory.

MY THIRD SELECTION of astronomical postage stamps is a gallery of observatories and instruments, both historic and modern. They span progress from an observing site in ancient Korea to radio telescopes and the great 200-inch reflector on Palomar Mountain.

In a handsome United States postal design, the dome of the latter instrument is pictured at the top of this page. Since beginning operation in 1948, the Hale telescope's main role has been to ascertain the large-scale structure of the universe.

The bowl of England's great 250-foot radio telescope at Jodrell Bank is on the Haitian stamp above. Below it we see one of the major telescopes at Tokyo Observatory, the largest astronomical institution in Asia, and at the right is a zenith telescope used in latitude measurements, a field in which Japanese astronomers have been pre-eminent.

The Pic du Midi, where Bernard Lyot used the first coronagraph to study the sun's outermost atmosphere, appears below on an attractive French stamp. Contrast this with the recent Peruvian issue showing the ruins of the ancient temple of the sun at Cusco. Before the Spanish conquest, Inca astronomer priests there kept watch on the heavens in order to



When the 200-inch Hale reflector was dedicated at Palomar Observatory in 1948, the United States put out this 3-cent blue stamp. Two decades were needed to build the instrument, the world's largest optical telescope, which is located in southern California.

Japan issued this 8-yen, blue-green commemorative in 1949 to mark the 50th anniversary of the Mizusawa Latitude Observatory.

Left: This violet 40-franc French issue of 1951 pictures the Pic du Midi Observatory, situated in the French Pyrenees 8,800 feet above sea level. The stamp clearly shows the large dome containing the main instrument, a 23½-inch folded refractor. Right: The ruins of an old Inca solar observatory on a 2.20-sucre blue postal, issued by Peru in 1953.

Three recent Russian stamps illustrating various astronomical subjects. At the left, a brown, blue, and ocher 1957 stamp, 40 kopecks, shows an equatorial refractor being used for observations of sunspots. The other two stamps are part of a set of three commemorating the 1958 meeting of the International Astronomical Union in Moscow. The blue and brown one (center), also 40 kopecks, pictures a large solar tower at the Crimean Astrophysical Observatory; the Sternberg Astronomical Institute's 28-inch reflector is on the dark blue and brown, one-ruble stamp at the right.

This 1948 14-weun blue stamp of Korea depicts a "chumsung dai" near Kyung Ju. This is a 1,300-year-old astronomical observing tower. The Sung Kyun Kwan University in Seoul plans to construct a new observatory to revive Korean interest in the science of astronomy.

regulate their calendar. Another ancient observatory is seen at the left, a monument of a period of astronomical activity 1,300 years ago in Kyung Ju, at that time the capital of Korea.

Many recent stamps have marked the International Geophysical Year. Among these is the Russian one (top left) depicting a modern refractor in use to observe the sun. Intensive study of the sun and its changes formed a major part of the IGY program, whose time span was chosen to include the peak of the 11-year cycle of solar activity.

The solar-tower stamp at top center portrays a part of Russia's main center for research in astrophysics, the Crimean Astrophysical Observatory, where N. A. Kozyrev's startling observation of gaseous emission on the moon was made last November (see page 184, February issue). Another Soviet stamp (bottom left) shows the main building of Moscow University.

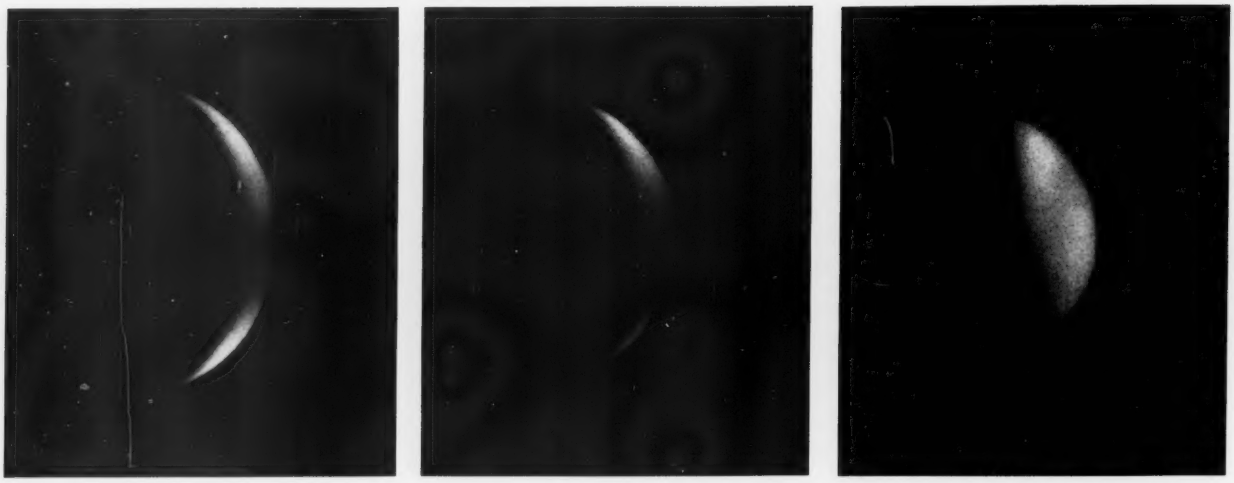
South American astronomy of the present day is represented by a stamp of Colombia, on which appears the national observatory at Bogota, best known as a center of geodetic work. Another radio telescope, this one at Ondrejov, Czechoslovakia, is depicted at the lower right.

(To be continued)

Colombia's national observatory at Bogota appears on a 5-centavo fawn stamp of 1946. The observatory was founded in 1803 by Jose Celestino Mutis. A blue stamp of the same design, issued in 1948, marked the observatory's 145th year.

Left: Another 1958 Russian stamp (60 kopecks, violet, light blue, and green-yellow) honoring the IAU. Pictured is Moscow University's main building, where the union held most of its sessions.

Right: The radio telescope represented on this Czechoslovakian issue of 1957 (30 haleru, violet-brown and yellow) is one of two 7.5-meter paraboloids.



These photographs of the planet Venus were taken at Pic du Midi Observatory in France by H. Camichel, using a 15-inch telescope. The dates were October 3, October 9, and November 6, 1943, when Venus was in the morning sky between inferior conjunction and greatest western elongation. Thus, as the planet receded from the earth, its apparent diameter lessened, while the crescent broadened. The extreme tips of the crescents do not show, as the observer sought to avoid overexposure of the delicate dark and bright markings that are so difficult to photograph. Although these are for the most part transitory features of the thick cloud layer of Venus, some observers, such as A. Dollfus of Meudon Observatory, believe that they have glimpsed more stabilized features through rifts in the clouds. All planetary pictures with this article are from the Pic du Midi Observatory, University of Toulouse.

Planet Notes from Moscow

JOSEPH ASHBROOK, *Harvard College Observatory*

WHICH BRANCHES of astronomy have been gaining in relative importance in recent years, and which are becoming less active? Meetings of the International Astronomical Union give good opportunity for this kind of stocktaking. At the 10th congress in Moscow last August, it was evident that planetary astronomy has begun a new period of flourishing growth.

The introduction of artificial satellites has been a major stimulant to interest in this field. Already they have greatly advanced our knowledge of the outermost layers of the earth's atmosphere, thereby offering new insight into the problems of planetary atmospheres. The surface of the moon may soon be subjected to close-up scrutiny, and eventually it will be explored directly.

Radio astronomy has become a powerful tool for planetary study at wave lengths from one centimeter to 15 meters, and radar pulses are being used to investigate the surface texture of the moon. In addition to these newer techniques, the more conventional observational methods of stellar astrophysics are being applied on an ever-increasing scale to solar system objects.

Martian problems were under discussion at this session of IAU Commission 16 in Moscow last August. In the foreground is C. Luplau Janssen (Denmark), while at the table behind him sit G. P. Kuiper (U. S. A.), right, and the author, left.

Commission 16 of the IAU is concerned with the physical study of planets and satellites, as distinguished from their orbital motions. Its chairman is Gerard P. Kuiper, of Yerkes and McDonald Observatories, whose commission report gives a broad and exciting view of recent progress in this area. A few of the highlights are reviewed here.

The planet Venus has been under intensive observational attack, though many of its mysteries still resist solution. The French astronomer Audouin Dollfus has made extensive measurements of the polarization of its light, from which he could deduce the atmospheric pressure at the level of the planet's cloud layer as 0.09 that at the earth's surface. Irregularities in the distribution of the polarization over the disk of Venus suggest striations in its cloud cover.

On August 28, 1956, while observing Venus visually with the 82-inch McDonald reflector at 900x, Kuiper and A. P. Lenham saw the illuminated portion of the disk broken up into hundreds of tiny bright spots, superficially not unlike the granulation of the sun's disk. A similar appearance has been seen by the Greek astronomer J. Focas, with the 16-inch refractor of Athens Observatory.

New information about the luminescence of the night side of Venus has been obtained. Some years ago, N. A. Kozyrev's spectra taken with the 50-inch reflector of the Crimean Astrophysical Observatory showed nitrogen emission features characteristic of terrestrial aurorae, and he estimated the brightness of the Venus night sky as 50 times the earth's. Some of these spectral features have now been confirmed by G. A. Newkirk, Jr., at the

High Altitude Observatory in Colorado, who has recorded emissions at 4140, 4188, and 4278 angstroms in the spectrum of Venus' night side.

Observations of the earth itself as an astronomical body were described to Commission 16 by J. Rösch, who is director of Pic du Midi Observatory in France. The sunlit side of the earth is bright enough to illuminate conspicuously the dark side of the crescent moon, particularly a few days before and after new moon. The albedo or reflecting power of the earth can be determined by measuring the intensity of earthshine.

Rösch described a visual photometer designed for this purpose. A 3-inch telescope contains an auxiliary optical system so that two images of the moon are formed, tangent to one another. One image is dimmed with an optical wedge until its weakened lunar crescent just matches the brightness of the dark half of the other moon image. The precision of a single measurement of earthshine made in this way is about ±0.02 magnitude. As part of the International Geophysical Year, observations with such instruments have been made in France, Belgian Congo, India, Ecuador, and other countries. This world-wide chain of stations thus provides for charting the earth's albedo over different geographical longitudes.

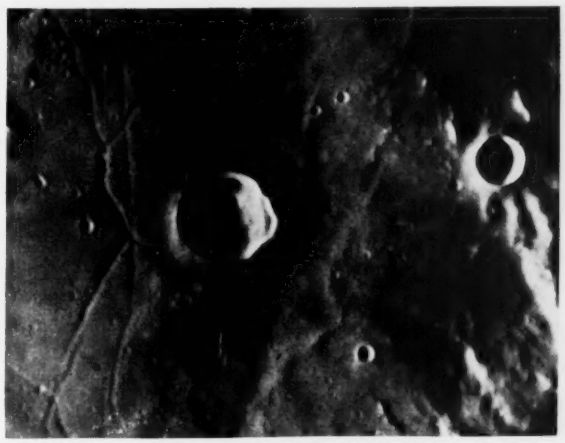
Much attention was paid by Commission 16 to Mars. The reformed nomenclature for Martian surface markings, adopted by the IAU on the commission's recommendation, has already been reported in SKY AND TELESCOPE for November, 1958, page 23. Only a small part of the very extensive world-wide observations of the red planet during the favorable 1956 opposition has so far been analyzed. In the U. S. S. R. the programs at several observatories were co-ordinated by a national Mars committee. Many photographs were taken at Kharkov, Stalinabad, Alma Ata, and Tashkent, to which Leningrad University sent an expedition. Image converters are coming into astronomical use in the Soviet Union, where A. A. Kalinjak has used one to photograph Mars in infrared light, at wave lengths of 8500 and 9500 angstroms.

Jupiter has been the particular object of a number of radio investigations, and the microwave temperatures of Venus, Mars, and Jupiter have all been determined. At a wave length of 3.75 centimeters, American scientists F. D. Drake and H. I. Ewen found the total emission from Saturn and its rings to be 4.3 times smaller than that from Jupiter.

H. Jeffreys and P. J. Message in England have made theoretical studies of the interior structure of the giant planets. They find that while Jupiter has only five per cent of its mass concentrated in a central body, Saturn has about 17 per cent. The absolute values of the central masses of these two giant planets are thus nearly equal, which agrees with the belief of Kuiper that the protoplanet (planet-in-formation) masses of Jupiter and Saturn were nearly the same. W. C. DeMarcus, of the University of Kentucky, calculates from the thermal and mechanical properties of hydrogen and helium that Jupiter is at least 78 per cent hydrogen and Saturn at least 63 per cent.

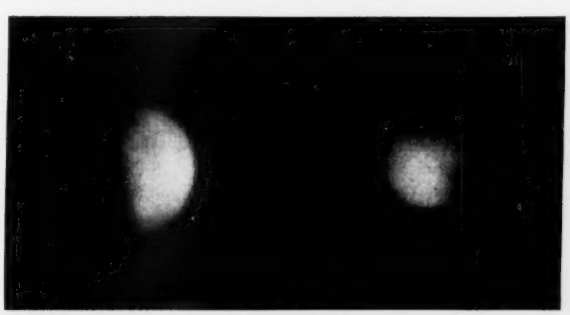
The most significant new lunar work is perhaps the recording of radar echos reflected from the moon. At a wave length of 1.5 meters, the returned pulses are so sharp that evidently the moon's surface is rather free of irregularities of around that size. Such observations at the Naval Research Laboratory and at Jodrell Bank Experimental Station show that half the energy of the reflected beam comes from the central one per cent of the moon's disk, as if the moon resembled a spherical mirror. Similar near-specular reflection can be observed on the earth above dry, sandy soil.

At the commission meeting, Kuiper told of progress in the preparation of his photographic atlas of the moon, and exhibited a fine proof sheet of the crater Ptolemaeus, from a negative taken with the 100-inch Mount Wilson reflector. The atlas is being compiled from the best moon photographs of Lick, Yerkes, McDonald, and Pic du Midi observatories. (Very few lunar photographs have been made with the 200-inch Hale telescope, and none under excellent seeing conditions.) In the atlas each portion of the moon will be shown under five different conditions of illumination — sunrise, morning, noon, afternoon, and sunset — except for limb regions, where some of these aspects are unobservable. Publication plans for this atlas are still uncertain, but the first installment of 150 sheets, each 16 by 15 inches, may appear in the middle of 1959.



Part of a lunar photograph taken with the 24-inch Pic du Midi refractor on March 21, 1945, at 20:45 Universal time. It shows the environs of the crater Triesnecker, 16.5 miles in diameter. Note the intricate system of shallow clefts west (left) of this crater. The small crater at the right is Chladni.

One general impression of planetary work gained at Moscow is that there are few branches of astronomy more in need of the collection and critical digestion of a great mass of observations into an orderly synthesis. A valuable effort has been V. V. Scharonov's recent book, *The Nature of the Planets,* a work which should be translated from Russian into English. Much is expected of the forthcoming Volume 3, dealing with the moon and planets, of *The Solar System,* edited by Dr. Kuiper. At present, however, the lack of books on planetary astronomy above the semipopular level remains a serious handicap.



Mercury is a difficult planet to photograph, yet these pictures by Bernard Lyot, with the 15-inch telescope at Pic du Midi Observatory, show some of the dusky markings visible to skilled visual observers. The photographs were made July 16, 1942 (left), and August 10, 1942 (right).

"SPACE HANDBOOK"

A 252-page publication of the U. S. Government Printing Office, entitled, *Space Handbook: Astronautics and Its Applications* has just been published, filling a long-felt need. Compiled by the Rand Corp., it is a staff report of the Select Committee on Astronautics and Space Exploration of the House of Representatives. It may be ordered from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 60 cents.

OBSERVING THE SATELLITES

Man in Space

THE APPROACHING DAWN of manned spaceflight is shown by several recent developments in Project Mercury. Although at least two years will intervene before the United States can place its first astronaut in orbit, the National Aeronautics and Space Administration is now making specific preparations. Shortly after contracts were given to McDonnell Aircraft Corp. for designing and building a re-entry vehicle, NASA's T. Keith Glennan announced the selection, by a committee of aero-medical specialists, of 110 candidates for the first manned orbital flight.

The candidates for the mission are engineers or physical scientists who are also trained test pilots. All are less than 40 years of age and not taller than five feet 11 inches. A series of thorough physiological and psychological tests will be used to make the final selection of the first American astronaut.

Some of the stresses that this man must face when the journey is finally undertaken can be simulated in advance in terrestrial laboratories. The most important physiological factor is the effect of the high accelerations during launching and re-entry upon blood circulation, especially the supply to the brain and central nervous system. However, the effects of the protracted weightlessness during orbital flight cannot be exactly duplicated, though planes can fly for a few minutes in parabolic trajectories, thereby providing some insight into human reactions.

Laboratory experiments can simulate many of the psychological stresses of spaceflight: the extreme isolation, the physical confinement, and the sharp reduction in the normal inflow of sensory stimuli. The actual effect of the venture's extreme hazard, however, will only be present in the real situation.

Without doubt, a main function of the first astronaut will be to serve as the subject of intensive medical experiment. During the flight, he will be under constant surveillance by the most elaborate physiological and psychological test equipment permitted by the vehicle's weight limitations. While it is likely that he will be carried in a system whose controls are largely automatic or ground-operated, he will have some control if an emergency develops.

The safety of this one man aloft is the present concern of hundreds of medical scientists. Their studies have included the careful determination of human responses to the exacting environment that will be encountered. Some of this work involves finding the limits of human tolerance to the air composition and pressure that may occur in a space capsule, as summarized in the accompanying chart.

Cosmic rays present a serious hazard. The kind of particles responsible for the Van Allen radiation belts, probed by Explorer III, is not definitely known, and their biological effectiveness requires much study. Perhaps the first manned flight will be planned for so low an altitude that little shielding will be needed.

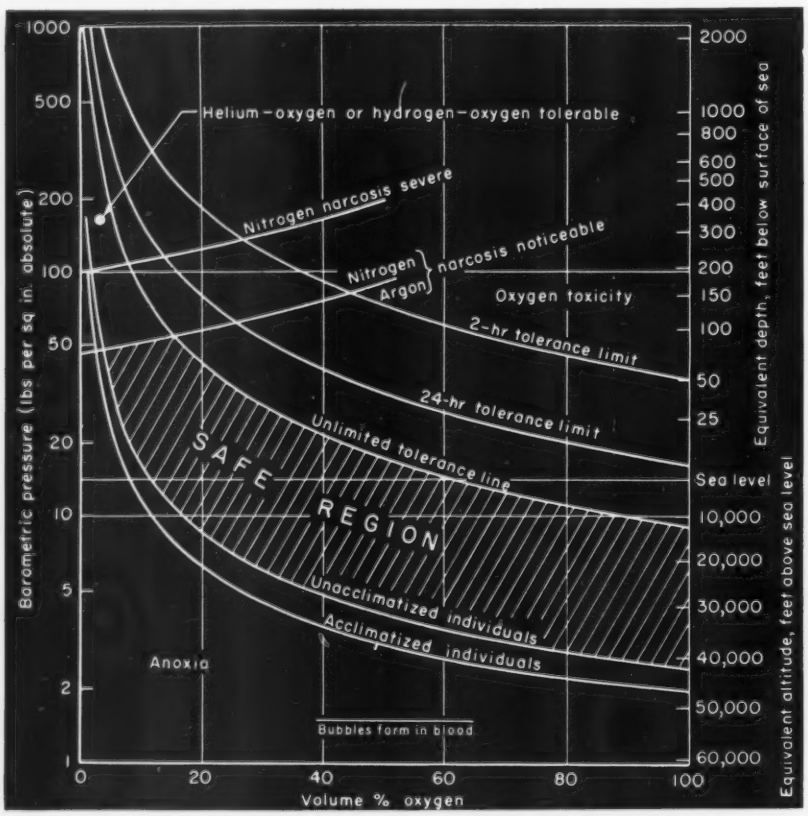
The space capsule for Project Mercury will be raised into orbit by an Atlas or other intercontinental ballistic missile, to which later stages will be added. The capsule is to be provided with an escape rocket, for possible use at lower altitudes. Another feature will be stabilizing jets for controlling its orientation in space.

One part of the capsule assembly requires a very precise adjustment — the retrorocket. The acceleration it imparts to start the re-entry phase must be closely controlled both as to amount and direction. If re-entry is too steep, atmospheric drag will be abrupt, and the pilot may be crushed under his own weight during the descent.

In the proposed design, the astronaut will be supported by a couch contoured to fit his back during the high accelerations of launching and re-entry. During the descent, a large heat shield is to be jettisoned, as a drag parachute opens at an altitude of perhaps 20 miles. Then a landing parachute will act to slow the vehicle to terminal velocity, and a cushion inflated to absorb the shock of landing.

Extensive tests of the re-entry vehicle are planned in the ensuing months, and some of these will involve the use of animals.

One purpose of the series of Discoverer satellites to be launched from the West Coast by the Advanced Research Projects Agency will be to gain supporting information for Project Mercury. However, it is currently planned that the first American manned spaceflight will be from Cape Canaveral, Florida.



Human tolerance to atmospheric environment in terms of oxygen volume and total pressure is shown by this chart from the "Space Handbook," prepared by the Rand Corp. (see page 259). The inert components of the atmosphere are taken as nitrogen, helium, hydrogen, and argon. If the inert diluent is helium alone, pressures of even 12 or more atmospheres may be tolerable.

Observing a Polar Satellite

NEW PROBLEMS are raised for observers of artificial satellites as Vandenberg Air Force Base, near Lompoc, California, joins Cape Canaveral as a satellite launching site. Some of the satellites to be sent up from the West Coast are to pass directly over the earth's poles. These polar satellites have some interesting properties quite distinct from those with lower inclinations.

The orbits of our previous satellites had inclinations of either about 32 degrees (Explorers I and III, Vanguard I, and the orbiting Atlas that fell over the Pacific on January 21st), or about 50 de-

grees (Explorer IV). All three Soviet Sputniks were launched at inclinations around 65 degrees. For the previous American satellites, the orbit plane swings slowly westward, while the perigee point advances along the orbit in the same direction as the satellite moves. Both these orbital changes are slower for an inclination of 65 degrees.

On the other hand, the orbit plane of a polar satellite, which is perpendicular to that of the earth's equatorial bulge, does not regress. While the plane is fixed with respect to the stars, the earth's orbital motion causes it to appear to shift relative to the sun, as seen below in the diagram. If an observer notes the polar satellite at the same solar time on successive days, it appears farther and farther west. However, the perigee point does shift, and in the direction opposite to the satellite's motion in its orbit.

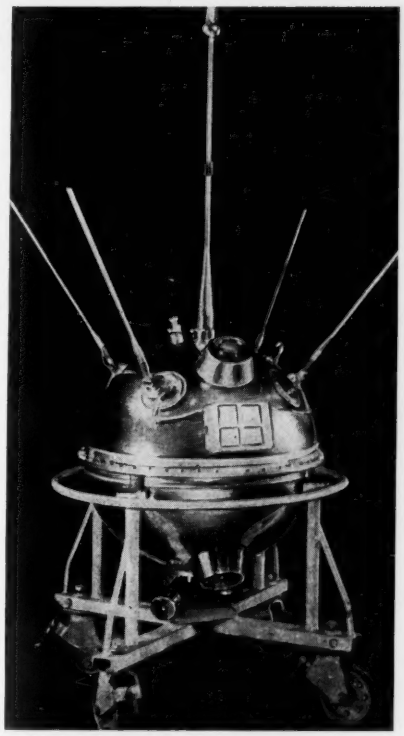
The time of day when a polar satellite is launched will determine whether optical observations will be possible. If the launching site is then in twilight, the satellite will continue to revolve around the earth inside the twilight zone for at least several days, and hence will be observable.

The best condition for continued visibility would be a launching just at the end of morning twilight. Since the satellite would be a degree farther west each day, relative to the sun, twilight sightings could continue for several weeks or more, the duration depending on the height of the vehicle. Similarly, there is a favorable launching time at the end of evening twilight. However, should the firing be made either in broad daylight or near the middle of the night, months might pass before optical observations would become possible, except from polar latitudes.

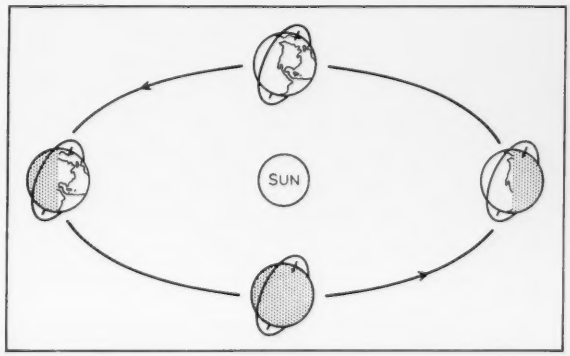
To an observer watching the crossing of a polar satellite, its motion will be almost, but not quite, along a north-south line. The difference is due to the earth's rotation carrying the observer eastward while the satellite is crossing. If this takes 12 minutes, for example, the earth will have turned through three degrees in the interval.

Visual observers of the earlier satellites have been accustomed to scan their meridians during search, and the arrangement of the instruments at many Moonwatch stations has been to form a meridian fence. Polar satellites, however, will rarely cross the meridian while above the horizon. For such objects, if a single line of observation is established, it should run east-west, covering the prime vertical (the great circle through the zenith and the east and west points of the horizon), rather than the meridian.

This will be necessary for early searches. But after there is enough information regarding the orbit, the observer may prefer to look for the satellite at the point in the sky where it should first become visible during a crossing. The computations for such a prediction are comparatively simple for polar orbits. Instructions for them can be obtained from the writer by serious satellite observers who send a stamped self-addressed envelope.



The instrument package of "Mechta," the Russian space probe, sits on an assembly carriage. Its payload was 796 pounds of equipment and batteries. The photographs on this page are from the U. S. S. R. Embassy, Washington, D. C.



As the earth revolves around the sun, its axis maintains the same orientation with respect to the stars (the phenomenon that causes the seasons). The diagram shows that in a similar fashion the orbital plane of a polar satellite will remain unchanged with respect to the stars.

More About "Mechta"

NOT ONE but two artificial planetoids have gone into orbit around the sun as a result of the "Mechta" launching on January 2nd (page 197, February). This is indicated by an interview with A. M. Kasatkin, of the Soviet rocket and satellite working group:

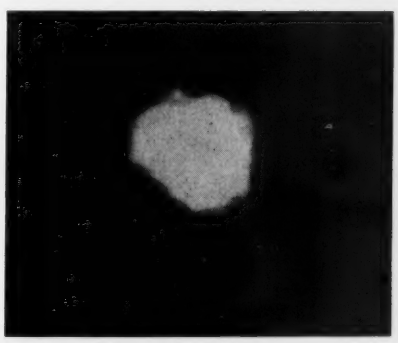
"The multistage space rocket . . . took off . . . and by the end of the launching phase the rocket's final stage had gained enough speed to continue its flight. The automatic guidance system of the final stage switched off the engine and signaled for the container with package of scientific instruments to disengage itself. The container and the final-stage rocket started on their course toward the area of the moon along close-lying paths."

Mr. Kasatkin described the instrument package as a hermetically sealed sphere, filled with gas at 1.3 atmospheres pressure, its temperature to be maintained at 68° Fahrenheit. As seen in the picture, the aluminum-magnesium sphere carried four antennas, grouped around a hollow aluminum pin, which was tipped with a transducer to measure the magnetic fields of the earth and the moon. Also on the casing were two proton traps to detect interplanetary gases, and two piezoelectric pickups to record meteoritic impacts.

Other instrumentation included two particle counters to measure cosmic ray intensity and two scintillation-type counters to study the composition of cosmic rays. The scientific apparatus and the two radio transmitters were powered by silver-zinc storage batteries and by mercury-oxide cells.

A widely observed cloud of luminous sodium vapor was discharged from "Mechta" when it was about 70,000 miles from the earth and nearly in the direction of the star Iota Virginis. The total amount of sodium was one kilogram. According to Mr. Kasatkin, the closest approach of the probe to the moon was "5 to 6 thousand kilometers," roughly $1\frac{1}{2}$ times the lunar diameter.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.



This picture of the sodium-vapor cloud ejected by the Soviet space probe was taken January 3, 1959, at 00:56:20 Universal time, by M. N. Gnevyshev at Kislovodsk Observatory in the Caucasus.

GETTING ACQUAINTED WITH ASTRONOMY

TIME AND THE SKY — III

HAVE you ever seen the planet Uranus? Identifying this slowly moving 6th-magnitude object among the stars is a good example of the usefulness of the sky co-ordinates, right ascension and declination. The amateur who has some understanding of them will be able to look in the right place for a newly discovered comet or nova, or for a star cluster or nebula.

The co-ordinate grid of right ascension and declination on a star map is closely analogous to the longitude and latitude grid on a map of the earth's surface. These geographical co-ordinates, therefore, make a useful starting point in describing their celestial counterparts.

TERRESTRIAL CO-ORDINATES

The definition of geographical latitude and longitude begins with the rotation of the earth on its axis. The axis meets the surface at the North and South Poles, and the great circle midway between them is the terrestrial equator.

The distance of a place north or south of the equator is given by its latitude, in degrees, minutes, and seconds. Places with north (+) latitude are in the Northern Hemisphere, those with south (−) latitude in the Southern Hemisphere. The latitude of the geographical North Pole is +90°, of the South Pole −90°.

To specify one particular spot fully, we need a second co-ordinate line, a meridian extending from pole to pole at right angles to the circles of latitude. We call the zero meridian that one passing through the original site of the Royal Greenwich Observatory near London, England. Then the longitude of the place in question is the distance in degrees, measured along the equator, from where it meets the zero meridian to the intersection of the place's meridian. Longitude is counted east (−) or west (+) from Greenwich, up to 180°. Places with east longitude are in the Eastern Hemisphere, those with west longitude in the Western Hemisphere.

Circumpolar star trails above the carillon tower at Wellesley College in Massachusetts. Polaris is the short overexposed trail, about a degree from the true celestial pole. This photograph by John C. Duncan is from his textbook, "Astronomy," reproduced by permission of Harper and Bros.

RIGHT ASCENSION AND DECLINATION

Just as the location of a city on the surface of the earth can be specified by its geographical latitude and longitude, so can the position of a star on the celestial sphere be fixed by the two co-ordinates declination and right ascension. To help visualize them, consider the diagram representing the concentricity of the earth and the celestial sphere. On the latter, infinitely larger than the earth, the north and south celestial poles and the celestial equator are analogous with their terrestrial counterparts.

The poles of the sky can be visualized as the centers of the apparent circles described by the stars as the earth rotates, and the celestial equator is midway between these poles.

The declination of a star is its distance in degrees north (+) or south (−) from the celestial equator. It is numerically equal to the geographical latitude of places from which the star can be seen in the zenith. For example, 1st-magnitude Vega (declination +38° 45′) passes almost directly over the U. S. Naval Observatory in Washington, D. C. (at latitude +38° 55′).

The half circle on the sky that serves the same purpose as the Greenwich meridian on earth is the one joining the celestial poles and passing through the March equinox. (The latter is the point in the heavens where the sun crosses the celestial equator from south to north each year; it has the co-ordinates right ascension 0^h, declination 0°.)

Right ascension differs from its counterpart, geographical longitude, in being counted eastward from the equinox all the way around the sky. Note that it increases eastward, opposite to the direction in which the sky seems to turn.

It is usual to express right ascension not in angular units but in hours (^{h}), minutes (^{m}), and seconds (^{s}) of time. The conversion is easy on the basis that 24 hours of sidereal time represent one full rotation of the sky, or 360 degrees. Thus $1^h = 15°$; $1^m = 15'$; and $1^s = 15''$. Conversely, $1° = 4^m$; $1' = 4^s$; and $1'' = 1/15^s$.

The abbreviations R. A. and α (alpha) are in common use for right ascension, as are Dec. and δ (delta) for declination.

PRECESSION

While the geographical longitude and latitude of a city remain the same from one year to the next (except for a very slight wandering of the pole), the right ascension and declination of a star change progressively. Thus Aldebaran at the beginning of 1950 had the co-ordinates: right

ascension $4^h\ 33^m.0$, declination $+16°\ 25'$, but at the start of 1960 it will be at $4^h\ 33^m.6$, $+16°\ 26'$. This change is almost entirely due to precession, a slow displacement of the co-ordinate system relative to the stars, caused by the 25,800-year conical wobble of the earth's rotational axis.

This means that the position of a star is not complete unless a date is given. Star atlases and catalogues are, therefore, correct only for a particular epoch, such as 1925.0 or 1950.0. The latter is now in very widespread use.

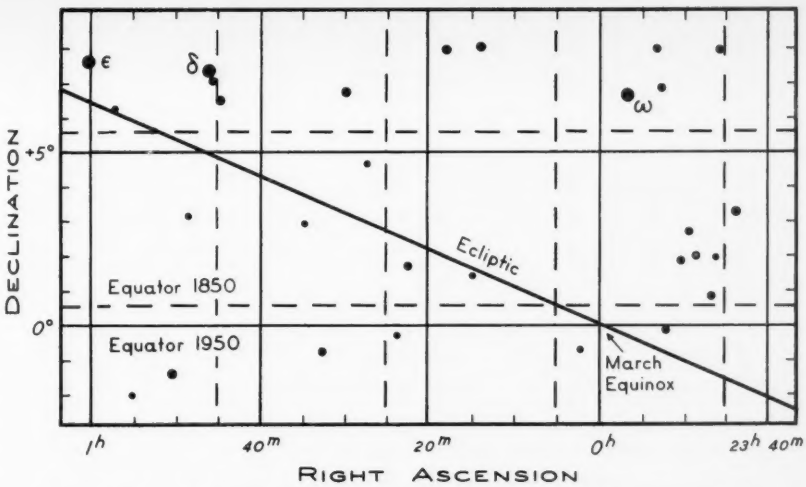
For many purposes of the amateur, the changes caused by precession over a few years are unimportant, but when more accuracy is needed, appropriate corrections must be applied. Tables for this purpose are given in many observing handbooks. Those provided here will suffice for all of the sky except near the celestial poles, where the precession in right ascension becomes so large as to need more elaborate treatment. The signs given in the tables are for precessing a position from an earlier to a later year; when precessing backward in time, the signs are to be reversed.

As an example, suppose the 1950.0 position of a star is known to be $18^h\ 40^m.0$, $-20°\ 00'$; what is the place for 1965.0? From the first table, we see that the change in right ascension is $+0^m.6$ in 10 years, or $+0^m.9$ in 15 years. The second table shows that the precession in declination will be about $+1'$ in 15 years. Therefore the 1965.0 position of the star will turn out to be $18^h\ 40^m.9$, $-19°\ 59'$.

If, instead, we want the position of the same star for 1935.0, then the precession backward from 1950.0 is $-0^m.9$, $-1'$, giving $18^h\ 39^m.1$, $-20°\ 01'$.

In the *American Ephemeris*, the right ascensions and declinations predicted for the sun, moon, and planets from Mercury to Neptune are *apparent places*. These differ from the positions referred to the co-ordinate system for the beginning of the year by a slight amount, generally well under a minute of arc.

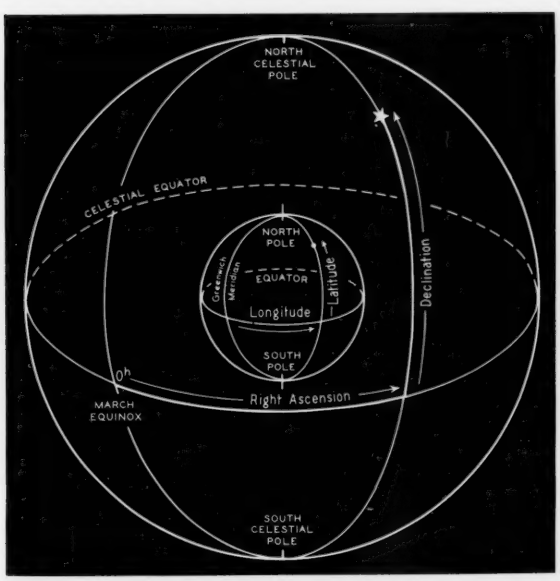
(To be continued)



A part of the sky near the March equinox, showing co-ordinates for 1850.0 (dashed lines) and 1950.0 (solid lines). The 100-year precessional shift is about five minutes in right ascension and half a degree in declination. The stars labeled with Greek letters are Epsilon, Delta, and Omega in Pisces.

10-YEAR PRECESSION IN RIGHT ASCENSION

R. A.	Declination +60°	+40°	+20°	0°	−20°	−40°	−60°	R. A.	Declination +60°	+40°	+20°	0°	−20°	−40°	−60°
	m	m	m	m	m	m	m		m	m	m	m	m	m	m
0h	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	12h	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5
1h	+0.6	+0.6	+0.5	+0.5	+0.5	+0.5	+0.4	13h	+0.4	+0.5	+0.5	+0.5	+0.5	+0.6	+0.6
2h	+0.7	+0.6	+0.6	+0.5	+0.5	+0.4	+0.3	14h	+0.3	+0.4	+0.5	+0.5	+0.6	+0.6	+0.7
3h	+0.8	+0.6	+0.6	+0.5	+0.5	+0.4	+0.2	15h	+0.2	+0.4	+0.5	+0.5	+0.6	+0.6	+0.8
4h	+0.8	+0.7	+0.6	+0.5	+0.4	+0.3	+0.2	16h	+0.2	+0.3	+0.4	+0.5	+0.6	+0.7	+0.8
5h	+0.9	+0.7	+0.6	+0.5	+0.4	+0.3	+0.1	17h	+0.1	+0.3	+0.4	+0.5	+0.6	+0.7	+0.9
6h	+0.9	+0.7	+0.6	+0.5	+0.4	+0.3	+0.1	18h	+0.1	+0.3	+0.4	+0.5	+0.6	+0.7	+0.9
7h	+0.9	+0.7	+0.6	+0.5	+0.4	+0.3	+0.1	19h	+0.1	+0.3	+0.4	+0.5	+0.6	+0.7	+0.9
8h	+0.8	+0.7	+0.6	+0.5	+0.4	+0.3	+0.2	20h	+0.2	+0.3	+0.4	+0.5	+0.6	+0.7	+0.8
9h	+0.8	+0.6	+0.6	+0.5	+0.5	+0.4	+0.2	21h	+0.2	+0.4	+0.5	+0.5	+0.6	+0.6	+0.8
10h	+0.7	+0.6	+0.6	+0.5	+0.5	+0.4	+0.3	22h	+0.3	+0.4	+0.5	+0.5	+0.6	+0.6	+0.7
11h	+0.6	+0.6	+0.5	+0.5	+0.5	+0.5	+0.4	23h	+0.4	+0.5	+0.5	+0.5	+0.5	+0.6	+0.6
12h	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	24h	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5



The relations between two co-ordinate systems, latitude and longitude on the earth and declination and right ascension in the sky, are illustrated here. The celestial poles, as determined from the daily circles of the stars (pictured opposite), are the starting points of both systems. The terrestrial poles lie along the same line as the celestial ones. The half circle running from the north celestial pole through the March equinox to the south celestial pole is part of the circle in the sky known as the equinoctial colure.

10-YEAR PRECESSION IN DECLINATION

R. A.		R. A.	
0h	+3′	12h	−3′
1h	+3′	13h	−3′
2h	+3′	14h	−3′
3h	+2′	15h	−2′
4h	+2′	16h	−2′
5h	+1′	17h	−1′
6h	0	18h	0
7h	−1′	19h	+1′
8h	−2′	20h	+2′
9h	−2′	21h	+2′
10h	−3′	22h	+3′
11h	−3′	23h	+3′
12h	−3′	24h	+3′

ISSEI YAMAMOTO DIES

One of Japan's outstanding astronomers, Issei Yamamoto, died on January 16th. He was an internationally recognized authority on the zodiacal light, and compiled a valuable catalogue of comets. His other studies concerned sunspots and variable stars, while one of his latest published papers was a collection of meteor observations from early Japanese historical writings.

Dr. Yamamoto at one time worked at the International Latitude Observatory at Mizusawa, later becoming professor of astronomy at Kyoto University. On his retirement, he founded Tanakami Observatory – now called Yamamoto Observatory – in Shiga prefecture.

The author of many Japanese books on astronomical subjects, Dr. Yamamoto actively supported amateur astronomy.

About 40 years ago he organized the Oriental Astronomical Association, to this day one of the most important amateur groups in Japan, and edited its journal *Tenkai* (The Heavens).

NEW YORK ORDERS PROJECTOR

Since October, 1935, when the American Museum-Hayden Planetarium first opened its doors in New York City, 10 million persons have attended demonstrations with its Zeiss projector. Now, with funds from the Charles Hayden Foundation, a new instrument has been ordered to replace the old projector before increasingly heavy use results in a breakdown. The Carl Zeiss Co., in Oberkochen, West Germany, expects to make delivery within a year.

Planetarium Notes

(Most planetariums give group and special showings by appointment.)

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 5-2370.

SCHEDULE: (Sept.-June), Thursday, 7:15, 7:45, 9 p.m.; Saturday, 2 and 3 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BLOOMFIELD HILLS, MICH.: *McMath Planetarium.* Cranbrook Institute of Science, Bloomfield Hills, Mich.

SCHEDULE: Saturday and Sunday, 2:30 and 3:30 p.m.; Wednesday, 4 p.m. Spitz projector. In charge, James A. Fowler.

BOSTON: *Charles Hayden Planetarium.* Museum of Science, Science Park, Boston 14, Mass., Richmond 2-1410.

SCHEDULE: Tuesday through Friday, 11 a.m. and 3 p.m.; Friday, 5:30 and 8 p.m.; Saturday, 11 a.m., 2 and 3:30 p.m.; Sunday, 1:30, 2:45, and 4 p.m. Korkosz projector. Director, John Patterson.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N. C.

SCHEDULE: Daily, 8:30 p.m.; also at 11 a.m. and 3 p.m. Saturday, 3 and 4 p.m. Sunday. Zeiss projector. Manager, A. F. Jenzano.

CHARLESTON, W. VA.: *Hillis Townsend Planetarium.* Children's Museum, Public Library Building, Charleston, W. Va.

SCHEDULE: Saturday, 11 a.m. Admission free. Spitz projector. Director, Mrs. R. L. Sullivan.

CHATTANOOGA, TENN.: *Clarence T. Jones Observatory.* Brainerd Rd., Chattanooga, Tenn., MA 2-5733.

SCHEDULE: Friday, 8 p.m. Admission free. Jones projector. Astronomer in charge, Karel Hujer.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Dr., Chicago 5, Ill., Wabash 2-1428.

SCHEDULE: Monday through Saturday, 11 a.m. and 3 p.m.; Tuesday and Friday, 8 p.m.; Sunday, 2 and 3:30 p.m. Zeiss projector. Director, Albert Shatzel.

COLORADO SPRINGS: *Academy Planetarium.* U. S. Air Force Academy, Colorado Springs, Colo., Granite 2-3608.

SCHEDULE: Wednesday, 8 p.m.; Saturday, 2:30 p.m.; Sunday, 2 and 3 p.m. Admission free. Spitz Model B projector. Director, Major Floyd C. Ethridge.

DALLAS: *Dallas Planetarium.* Dallas Health Museum, Fair Park, Dallas 10, Tex., HA 8-8351.

SCHEDULE: Saturday and Sunday, 3 p.m. Spitz projector. Planetarium educator, Mrs. Claudia Robinson.

DENVER: *Denver Museum of Natural History Planetarium.* City Park, Denver, Colo., East 2-1808.

SCHEDULE: Saturday and Sunday, 1 to 4:30 p.m. Spitz projector. Curator, W. R. Van Nattan.

FLINT, MICH.: *Robert T. Longway Planetarium.* Flint Junior College, 1310 E. Kearsley St., Flint 3, Mich., Cedar 8-1631.

SCHEDULE: Tuesday through Saturday, 8 p.m.; Saturday and Sunday, 2 p.m. Spitz Model B projector. Director, M. G. Moore.

FT. WORTH: *Charlie M. Noble Planetarium.* Ft. Worth Children's Museum, 1501 Montgomery, Ft. Worth, Tex., PE 2-1461.

SCHEDULE: Tuesday through Friday, 4:15 p.m.; Saturday, 11:15 a.m. and 2:15 p.m.; Sunday, 2:15 p.m. Spitz projector. Supervisor, Norman C. Cole.

INDIANAPOLIS: *Holcomb Planetarium.* Butler University, Indianapolis 7, Ind.

SCHEDULE: Saturday and Sunday, 4 and 8 p.m. Spitz projector. Director, H. Crull.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 23, Mo., Humboldt 3-8000.

SCHEDULE: Saturday and Sunday, 3 p.m. Spitz projector. Acting director, Wilber E. Phillips.

LANCASTER, PA.: *North Museum and Planetarium.* Franklin and Marshall College, Lancaster, Pa.

SCHEDULE: Tuesday and Thursday, 8 p.m.; Saturday and Sunday, 3 p.m. Admission free. Spitz projector. Curator, John W. Price.

LAQUEY, MO.: *Tarbell Planetarium.* Inca Cave Park, Laquey, Mo.

SCHEDULE: Sunday, 1 to 6 p.m., continuous. Spitz projector. Director, E. D. Tarbell.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 27787, Los Feliz Station, Los Angeles 27, Calif., Normandy 4-1191.

SCHEDULE: Daily (except Monday), 3 and 8:30 p.m.; also 1:30 and 4:15 p.m. Saturday and Sunday. Zeiss projector. Director, C. H. Cleminshaw.

MINNEAPOLIS: *Science Museum.* Minneapolis Public Library, 1001 Hennepin Ave., Minneapolis 3, Minn.

SCHEDULE: Saturday, 10 a.m. and 2 p.m. Admission free. Spitz projector. Planetarium director, Mrs. Maxine B. Haarstick.

NASHVILLE: *Sudekum Planetarium.* Children's Museum, 724 2nd Ave. S., Nashville 10, Tenn., Chapel 2-1858.

SCHEDULE: Sunday, 2:45, 3:30, 4:15 p.m. Spitz projector. Director, Jacqueline Avent.

NEWARK: *Newark Museum Planetarium.* 49 Washington St., Newark 1, N. J., Mitchell 2-0011.

SCHEDULE: Saturday, Sunday (except first Sunday of month), and holidays, 2:30 and 3:30 p.m. Admission free. Spitz projector. Supervisor, Raymond J. Stein.

NEW YORK CITY: *American Museum-Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Trafalgar 3-1300.

SCHEDULE: Monday, 2 and 3:30 p.m.; Tuesday through Friday, 2, 3:30 and 8:30 p.m.; Saturday, 11 a.m., 1, 2, 3, 4, 5 and 8:30 p.m.; Sunday and holidays, 1, 2, 3, 4, 5 and 8:30 p.m. Zeiss projector. Chairman, J. M. Chamberlain.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesday through Sunday, 3 p.m.; Saturday, 11 a.m.; Saturday, Sunday, and holidays, 2 p.m.; Wednesday and Friday, 8 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 1-4300.

SCHEDULE: Daily, 2:15 and 8:30 p.m.; also at 11 a.m. Saturday and 4:15 p.m. Sunday. Zeiss projector. Director, Arthur L. Draper.

PROVIDENCE: *Roger Williams Planetarium.* Roger Williams Park Museum, Providence 5, R. I., Williams 1-5640.

SCHEDULE: Saturday, Sunday, and holidays, 3 and 4 p.m. (Oct. 1-May 30). Admission free. Spitz projector. Director, Maribelle Cormack.

SAN FRANCISCO: *Morrison Planetarium.* California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif., Bayview 1-5100.

SCHEDULE: Daily (except Monday and Tuesday), 3:30 and 8:30 p.m.; also 2 p.m. Saturday, Sunday, and holidays. Academy projector. Curator, George W. Bunton.

SAN JOSE, CALIF.: *Rosicrucian Planetarium and Science Museum.* Park Ave. and Naglee Ave., San Jose, Calif.

SCHEDULE: Sunday and Wednesday, 2 and 3:30 p.m. Spitz projector. Director, Rodman R. Clayson.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesday, Thursday, and Saturday, 3 p.m.; also 8:30 p.m. Tuesday; special star stories for children, Saturday, 2 p.m. Admission free. Korkosz projector. Director, F. Korkosz.

STAMFORD, CONN.: *Edgerton Planetarium.* Stamford Museum and Nature Center, Stamford, Conn., Davis 2-1646.

SCHEDULE: Saturday, 11 a.m.; Sunday, 4 p.m. Spitz projector. Director, Ernest T. Luhde.

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54 mm. (2⅛")	330 mm. (13")	**12.50**	83 mm. (3¼")	762 mm. (30")	**28.00**
54 mm. (2⅛")	390 mm. (15.4")	**9.75**	83 mm. (3¼")	876 mm. (34½")	**28.00**
54 mm. (2⅛")	508 mm. (20")	**12.50**	83 mm. (3¼")	1016 mm. (40")	**30.00**
54 mm. (2⅛")	600 mm. (23½")	**12.50**	102 mm. (4")	876 mm. (34½")	**60.00**
54 mm. (2⅛")	762 mm. (30")	**12.50**	108 mm. (4¼")	914 mm. (36")	**60.00**
54 mm. (2⅛")	1016 mm. (40")	**12.50**	110 mm. (4⅜")*	1069 mm. (42-1/16")	**60.00**
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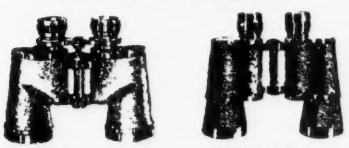

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7 x 50	372	"Zeiss"	**24.95**	**22.50**
7 x 50	372	American	**32.50**	—
8 x 30	393	"Zeiss"	**21.00**	**18.25**
10 x 50	275	"Zeiss"	**28.75**	**26.75**
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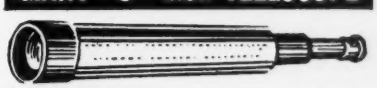

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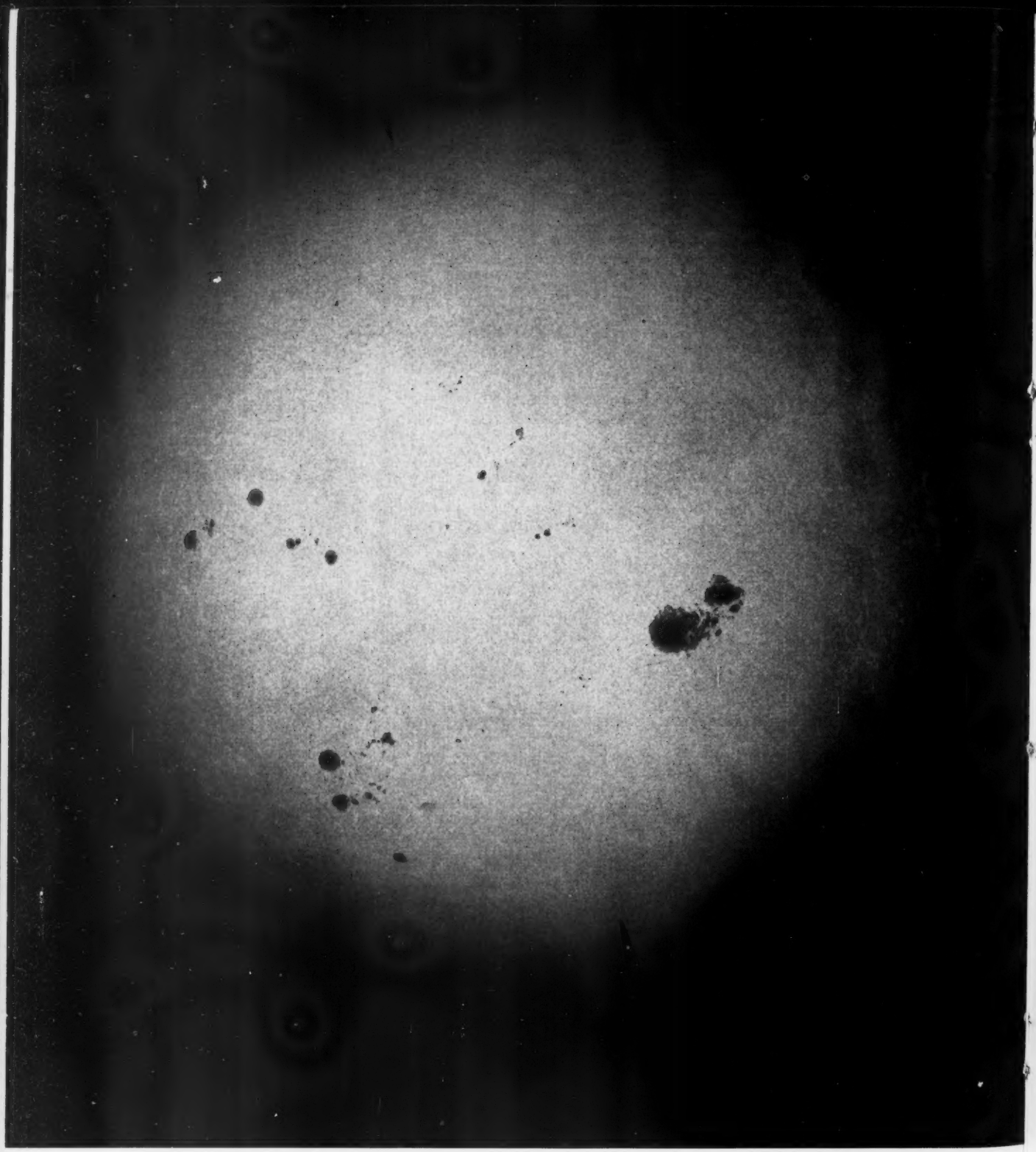


Although the principal program of the International Geophysical Year was scheduled to close at the end of 1958, solar and geophysical observations are being intensively carried on in many parts of the world. At Mount Wilson Observatory in California, daily sunspot counts, drawings, and photographs are made as part of a program begun half a century ago. Solar observer Joseph Hickox used the 60-foot tower telescope for this picture of the sun on January 9th, at 8:10:20 a.m. Pacific standard time, when the largest single sunspot group since 1951 was prominent on its disk. The dark central umbra of the great spot is surrounded by an extensive lighter penumbra of intricate form, containing numbers of minute spots. A short distance to the east (right) and slightly south (above) is another giant spot, whose area that day was 970, according to the U. S. Naval Observatory. The Zurich provisional sunspot number for this date was 245, which may be roughly checked by close inspection of this picture. Count each individual spot (umbra), no matter how small, and add to this total the number of groups multiplied by 10. The lower wedge-shaped indicator with the white dot marks the position of the sun's north pole. The reproduction has accentuated the normal darkening of the solar disk toward its limb (edge), where luminous high-floating clouds (faculae) are seen. Mount Wilson and Palomar Observatories photograph.

OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

JANUARY'S GREAT SUNSPOT GROUP

THE LARGEST GROUP of spots to appear on the sun since 1951 attracted world-wide attention from observers during the first part of January. At its peak development it stretched 100,000 miles across the sun's face, compared with 125,000 miles for the May, 1951, disturbance and 152,000 miles for the April, 1947, group, which is the largest on record.

A concise history of the great January spot group is afforded by the daily solar photographs taken at the U. S. Naval Observatory in Washington, D. C., with a horizontal camera of 40-foot focal length. Results from preliminary measurements of these plates have been made available; definitive measurements will be published later in the *Circulars* of the Naval Observatory.

The first Washington evidence was on January 4th, when the day's photoheliograph plate showed an enormous spot at the eastern edge of the sun, as it was being carried into view by the solar rotation. Its area, expressed in millionths of the visible hemisphere of the sun and corrected for foreshortening, was 679 — considerably more than for any other spot on the disk.

By the next morning the spot had grown, and on the 6th its area was 1,551. It could then be recognized as the leader of a string of major spots, stretching over 10 degrees of heliographic longitude, and centered on latitude +13°.

The principal spot reached its maximum area of 2,157 millionths on January 9th, when the Mount Wilson Observatory photograph on the facing page was taken. The next day, solar rotation carried it across the central meridian of the sun. The appearance of the group to an amateur astronomer in England is shown in the two drawings below. T. J. Martin, at Bexleyheath in Kent, used an 8-inch reflector for both. On January 10th, he projected the sun through a Barlow lens to form an image in which this sunspot group appeared an inch long. His second sketch, made on the afternoon of the 11th, is based on three photographs taken with this same equipment. The sun's image was eight inches in diameter, and the seeing was poor.

At Appleton, Wisconsin, on the morning of January 12th, J. J. Knuijt was able to see the spot group without optical aid. He writes:

"At 7:50 a.m. Central standard time, I happened to be looking at the eastern sky, where the sun was slowly becoming visible through a thin section of a stratus cloud bank. The red solar disk was so dimmed that I was able to look at it directly without shielding my eyes. I thought I saw an elongated black spot slightly above the center of the apparent solar disk, and repeated observations showed the phenomenon to be real. But in a few minutes the sun was once again hidden by clouds.

"I wanted to check my sighting of this naked-eye sunspot by using my 4-inch Clark refractor, but persistent cloudy weather from January 12th to 15th had prevented my doing so. Only on the evening of the 15th did I finally see a photograph of the sun taken at Mount Wilson, showing the large group that I had seen."

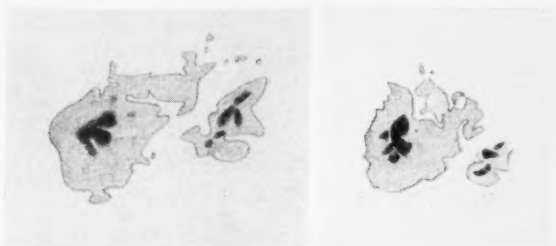
From January 12th onward, as the group moved toward the western limb of the sun, it decreased in size and became more complex. The preliminary Washington values for the area of the principal spot on January 12th, 13th, 14th, and 15th, were 1,333, 1,818, 1,770, and 1,527, respectively. On the last of these dates the region was near the western edge, about to be carried out of sight.

At heliographic latitude +13°, the sun's apparent rotation period, as indicated by sunspots, is about 27.3 days. Therefore, the great leading spot, if it lasts a long time, would again cross the solar central meridian about March 6th.

JANUARY AURORAS

Even though solar activity has tapered off considerably from its very high level last year, auroras are still being seen frequently. Reports of two displays during January have been received, the first from J. R. Otoupalik of Greeley, Colorado, who saw an auroral glow reaching about 20 degrees above the northern horizon at 8 p.m., Mountain time, on January 8th.

The next night northern lights were seen at Eightyfour, Pennsylvania, by David R. Kaiser. Despite clouds, he was able to watch them from 11 p.m. until after 2 a.m., Eastern standard time.



The left-hand drawing was made by T. J. Martin on January 10th at 12:30-13:30 Universal time, that at the right on January 11th at 13:00-13:30. Seeing was steady on the first day, but poor on the second.

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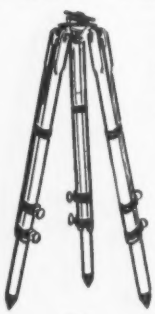

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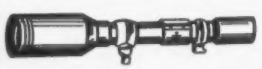

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PHOTOGRAPHS OF VENUS

Using my astrocamera described on page 188 of the February, 1956, SKY AND TELESCOPE, I took a series of pictures of Venus during its evening apparition in late 1957 and early 1958, from eastern elongation to near inferior conjunction. When the series was begun on November 12th, Venus was in declination −27° and was 52.9-per-cent illuminated. At the end, on January 17, 1958, the planet was a slender crescent only 5.3-per-cent illuminated.

The plate scale for all of these photographs was the same, the focal-plane image being enlarged 10 times by projection. The camera was similarly oriented for all pictures, so the turning of the crescent is part of the natural aspect of the planet during that period. An amber filter placed before the eyepiece was helpful in reducing sky fog, and I used a beam splitter to center the image on the plate. This device was removed just before the actual exposure, which ranged from 1/5 to 1/10 second.

The first pictures in the series were made near dusk; later in the series they were taken before sunset, as nearby trees interfered with the horizon.

HANS PFLEUMER
596 First Ave.
North Brunswick, N. J.

Three photographs from Hans Pfleumer's Venus series show the excellence of his results and the change of the planet's apparent size with phase. Top: November 17, 1957, Venus at declination −26°, 50-per-cent illuminated. Middle, December 23, 1957, −18°, 27-per-cent. Bottom, January 12, 1958, −13°, nine-per-cent.

GEMINID METEOR PHOTOGRAPHS

During the nights of December 12-13 and 13-14, 1958, I set up five cameras with the help of Robert Napier, to record the Geminid meteor shower. Forty 2¼-by-3¼ negatives were secured, each exposed from 30 minutes to an hour, and eight of them had a total of 12 meteor trails. The brightest, shown here, was recorded about 10:45 p.m. Eastern standard time, on the 12th, with a Kodak Medalist f/3.5 camera and a medium-speed film. Clouds spoiled the maximum of shower activity.

The track of a brilliant Geminid meteor recorded below the star trails of Castor and Pollux, by J. T. Hopf.

JOHN T. HOPF
10 Red Cross Terr.
Newport, R. I.

SUNSPOT NUMBERS

The following American sunspot numbers for December, 1958, have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

December 1, 255; **2**, 225; **3**, 191; **4**, 225; **5**, 226; **6**, 226; **7**, 207; **8**, 236; **9**, 263; **10**, 203; **11**, 215; **12**, 170; **13**, 220; **14**, 186; **15**, 116; **16**, 135; **17**, 116; **18**, 96; **19**, 71; **20**, 86; **21**, 94; **22**, 107; **23**, 102; **24**, 153; **25**, 173; **26**, 204; **27**, 186; **28**, 191; **29**, 143; **30**, 142; **31**, 173. Mean for December, 172.5.

Below are mean relative sunspot numbers by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

January 1, 201; **2**, 201; **3**, 207; **4**, 217; **5**, 243; **6**, 228; **7**, 233; **8**, 241; **9**, 245; **10**, 224; **11**, 218; **12**, 203; **13**, 192; **14**, 120; **15**, 120; **16**, 143; **17**, 168; **18**, 177; **19**, 202; **20**, 240; **21**, 248; **22**, 268; **23**, 255; **24**, 254; **25**, 250; **26**, 240; **27**, 253; **28**, 232; **29**, 203; **30**, 157; **31**, 136. Mean for January, 210.3.

DEEP-SKY WONDERS

MOST AMATEURS know that the declination of the southern horizon is equal to 90 degrees minus the latitude. Thus from latitude 40° north you can see down to declination −50°. Too often horizon haze and limitations of observing handbooks keep United States amateurs from exploring near this limit.

Nevertheless, the Milky Way south of Sirius is rich in galactic star clusters, many fine ones being within 10 or 20 degrees of the southern horizon. Wait for a cool March night long enough after the passage of a cold front so that no postfrontal clouds cover the distant southern hills, yet soon enough after for the air to be free of any fog or haze. Perhaps you know some country hilltop to which you can take your telescope for an unobstructed view of the southern sky. On such a night, the resplendent winter Milky Way expands below Sirius in pale billows.

As a warmup, try NGC 2362, a cluster at $7^h\ 16^m.6$, −24° 52′ (1950 co-ordinates). About 6′ in diameter, it surrounds the 4th-magnitude star Tau Canis Majoris, a triple with faint companions at 8″ and 14″ distance. Next, the observer can pick up NGC 2451 at $7^h\ 44^m.5$, −37° 47′, a large, scattered cluster of fairly bright stars, one being magnitude 4½. This grouping is not marked in the Skalnate Pleso *Atlas of the Heavens*.

Nearby is NGC 2477, a fine very open cluster about 25′ in diameter, at $7^h\ 50^m.5$, −38° 25′. Photographs of it show about 300 member stars.

Amateurs who live in the southern part of the United States will want to try for an unusual low-power object, NGC 2932, centered on $9^h\ 33^m.5$, −46° 43′, south and east of Lambda Velorum. Sir John Herschel, who discovered it on March 3, 1837, while in South Africa, describes it as an enormous cluster of 8th-magnitude stars and fainter, 1° or 1½° in diameter, "a sort of telescopic Praesepe. It may perhaps be regarded as a detached portion of the Milky Way, which is here very much broken up."

WALTER SCOTT HOUSTON
Rte. 3, Manhattan, Kans.

EARTH'S SHADOW DURING LUNAR ECLIPSES

It is well known that during eclipses of the moon the umbral shadow of the earth appears somewhat larger than predicted from the geometrical size of our planet. The November, 1958, issue of the *Bulletin* of the Astronomical Institutes of Czechoslovakia contains an analysis of observations during the partial eclipse of May 13-14, 1957.

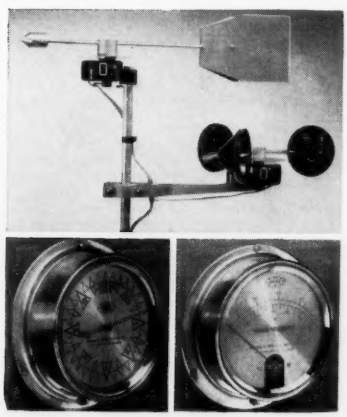
From 100 observed times when craters entered or left the shadow, obtained by eight Czechoslovakian observers, the enlargement of the umbra was found to be 1.8 per cent. This can be compared with 2.15 per cent at the total eclipse of November 17-18, 1956, as deduced from 42 times recorded by readers of SKY AND TELESCOPE (February, 1957, page 196).

The next two lunar eclipses visible in the United States will be on March 13, 1960, and September 5, 1960, and should provide favorable opportunities for American amateurs to make additional observations of this kind.

CHECKING OBSERVING SITES FOR THE OCTOBER ECLIPSE

On page 200 of the February issue, a map showed roughly the path of totality in eastern Massachusetts and southeastern New Hampshire at the total eclipse of the sun on October 2, 1959. The occurrence of mideclipse so soon after sunrise makes it important to check observing sites in advance to insure that the eastern horizon is not obstructed just where the sun will rise in October.

Such checking can be done, weather permitting, during the week of March 8th. At latitude 42½° north, in the Marblehead-Salem area (where the central line reaches the coast), the sun will rise about 7½° south of east on Sunday morning, March 8th, only 2½° in azimuth from its eclipse position. By March 12th, the sun's declination will be nearly the same as on October 2nd, and it will have the same rising point, azimuth 5° south of east. At Salem on the 12th, the Eastern standard time of sunrise (upper limb corrected for refraction) will be 6:01 a.m.



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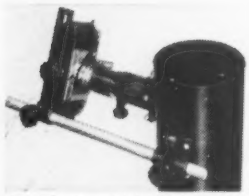

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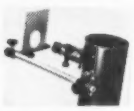

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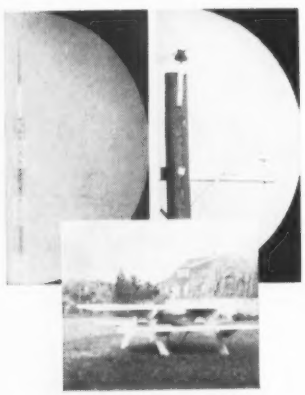

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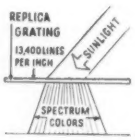

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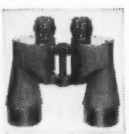

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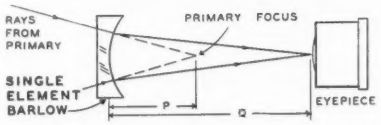
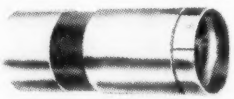
An excellent lens — can be adapted for use on 35-mm. and Speed Graphic cameras as a telephoto lens. Three of the first four pictures of Sputnik III were taken by a student with a homemade camera using one of these lenses. Adjustable diaphragm, f/16 to f/2.5. Gov't. cost over $400. War surplus.

Stock #70,161-Y.....$39.95 ppd.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Stock #30,200-Y Mounted Barlow lens.....$8.00 ppd.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y.....$16.25 ppd.

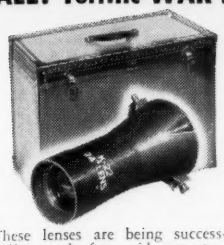
WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner Eyepiece, Type 3. 2 achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y.....$7.95 ppd.

EDMUND SCIENTIFIC CO.

SALE! Terrific WAR-SURPLUS BARGAIN! Made by B. & L. and E. K.



These lenses are being successfully used for wide aperture Moonwatch telescopes to see the small and fainter satellites. For eyepiece — use our GIANT ERFLE shown at right.

AERIAL CAMERA LENSES

Gov't. Cost $1218
Our Price, $39.50
Used; $59.50 New

24" f.l., f/6, in 23"-long lens cone

Mounted in beautiful brass cells, lenses are 4"-diam. precision 4-element type, Aero Tessar and Aero Ektar. Housed in cone — focal plane 10" beyond cone and permits building on a filmholder, eyepiece, etc. Lenses are easily removed for other uses. Diaphragm included — adjusts by flexible rod (easily extended) from f/6 to f/22. Opens approx. 1" to 3½". Lens and cone weigh 25 lbs. Sturdy carrying trunk weighs 26 lbs.

USES: 1. For long-range, Big Bertha telephoto lens. 2. For rich-field (wide-field, low-power) telescope. 3. As opaque projector lens. 4. In Operation Phototrack (photographing artificial satellites).

Stock #85,059-Y.....**24", used**.....**$39.50** f.o.b. Utah

Stock #85,060-Y.....**24", new**.....**$59.50** f.o.b. Utah

Send check or money order — Money-back guarantee.

8" SETTING-CIRCLE SET

Two 8"-diam. dials accurately printed on 1/16" thick black plastic, rigid and unbreakable. White figures on black background. Alternate black-and-white blocks designate divisions, allow easier reading — less eyestrain. ¼" pivot hole in center. Declination circle has 360° divided into 1° intervals, and reads from 0 to 90 to 0 to 90 to 0. Right-ascension circle has 24-hour scale divided into 5-minute blocks with two different scales on the same side. One reads from 0 to 6 to 0 to 6 to 0 hours and the other 1 to 24 hours consecutively. Instruction sheet included.

Stock #50,133-Y....Complete set.....**$3.00 ppd.**

Stock #60,078-Y....360° declination circle only **$1.60 ppd.**

Stock #60,079-Y....24-hour right-ascension circle only **$1.60 ppd.**

5¾" SETTING-CIRCLE SET

Same as described above but with 5¾"-diam. dials.

Stock #50,190-Y....Complete set.....**$2.50 ppd.**

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EQUATORIAL MOUNT and TRIPOD with CLOCK DRIVE

Heavy-duty mount. Drive operates on 110-volt, 60-cycle, a.c. house current. Follows motion of stars smoothly. 32" tripod legs included.

Stock #85,081-Y.....**$76.50** f.o.b. Barrington, N. J.

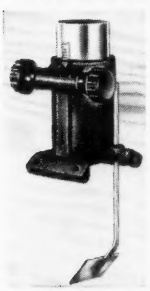
Same mount as above, without clock drive, for 8" or smaller reflectors and for 4" or smaller refractors.

Stock #85,023-Y.....New Low Price.....**$39.50** f.o.b. Barrington, N. J.

MOTORIZED CLOCK DRIVE (by itself) easily attached to your own mount. Instructions included.

Stock #50,198-Y.....**$36.95 ppd.**

Rack & Pinion Eyepiece Mounts



Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

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War Surplus

$200 Gov't. Cost—Only $13.50

Big 2" objective, focusing eyepiece 28-mm. focal length, Amici erecting system, turret-mounted filters of clear, red, amber, and neutral, reticle illumination. Sparkling, clear, bright image — 6° field (325 ft. at 1,000 yards). Focus adjusts 15 ft. to infinity. Eyepiece alone, 28-mm. focal length, is worth more than $12.50.

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War surplus — Alnico V type. Horseshoe shape. Tremendous lifting power. 5 lb. size. Dimensions:— A — 3¼"; B — 2¾"; C — 4-3/16"; D — 1¼"; E — 1¼"; F — 2⅝". Strength is about 2,000 Gauss. Will lift over 125 lbs.

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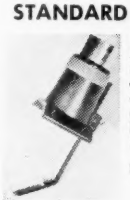
15¾-lb. size magnet. Approximately 5,000-6,000 Gauss rating. Will lift over 250 lbs.

Stock #85,088-Y ..... **$22.50** f.o.b. Barrington, N. J.

Shipping wt. 22 lbs.

STANDARD 1¼" EYEPIECE HOLDER



Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y.....**$2.50 ppd.**

PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y.....**$12.00 ppd.**

BE SURE TO GET FREE CATALOG "Y"

Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for Free Catalog "Y."

Sale! GIANT ERFLE EYEPIECE

Here is an exciting bargain. We have obtained a large lot of these eyepieces reasonably — so down goes the price to $9.95 for a real sale. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this lot is all sold, and triple and quadruple as years pass. If we didn't need to reduce our inventory, we'd be tempted to hold onto these eyepieces. Their wide apparent field is 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads; focusing adapter with 32 threads per inch is included; diameter is 2-11/16". If you don't order now and you miss out on a hundred-dollar eyepiece for only $9.95, you can't say that we didn't try to impress you with its value. You can make some super-duper finders with these eyepieces. They are also ideal for rich-field telescopes, which are becoming more popular daily, particularly in the Sputnik age. Everyone with a large reflecting telescope should have one of these.

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Sometimes the war-surplus end of this business is heartbreaking. Here is an excellent little telescope that cost Uncle Sam about $200.00. Makes a dandy finder with a 13° field. Weight 2 pounds, size 5¾" x 4½". Objective lens is an achromat, diameter 26 mm., focal length 104 mm. Amici roof prism with faces of 18 mm. x 20 mm. cost from $12.00 to $36.00 to make. Symmetrical eyepiece of 1¼" (32.5 mm.) effective focal length consists of 2 achromats with diameters of 34 mm. and focal lengths of 65 mm.

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Worth $60.00

Our Price $12.50

Made for use in $200 American reflex camera — now surplus because of a design change. You get both camera lens and shutter and viewing lens f/3.5, 83-mm. F.L., coated. Shutter speeds to 1/400 second.

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Elger's MAP OF THE MOON

The chart of the moon itself is 18 inches high by 17½ inches wide and identifies all the important lunar features. Below the map are notes by H. P. Wilkins on 146 of the more interesting areas. Printed on a sheet of paper 30 by 19½ inches and mounted on heavy canvas, the map is ideal for framing. **$3.00**

COLOR MAP OF THE NORTHERN HEAVENS

(Formerly called "Mappa Coelestis Nova")

This is a large wall chart, 30 by 34½ inches, colorful as well as informative. The northern sky to −45° is shown on a polar projection, and each star is colored according to its spectral class. Stars brighter than magnitude 5.1 are included. The map is mailed unfolded in a heavy tube. **$2.00**

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Unless otherwise specified, the previous numbers of *Sky and Telescope* to which references are made in articles and departments are available at 50 cents per copy. Since January, 1955, the numbers for January, February, September, and October, 1956, that of January, 1957, and those of March and April, 1958, are out of print. Many issues before January, 1955, are available; write for information on particular copies.

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BOOKS AND THE SKY

PHYSICS AND PHILOSOPHY

Werner Heisenberg. Harper and Brothers, New York. 1958. 206 pages. $4.00.

NO DEVELOPMENTS in recent time have so shaken human complacency as have those in the physical sciences, through both their material consequences and their intellectual implications. This impact upon accepted modes of thought has been especially sharp in the past 60 years, with the advent of relativity and quantum physics and the consequent modification of the mechanistic interpretations that had dominated scientific thought. When a leader in these changes writes of the meaning and implications of his work, he is worth reading.

Much of Werner Heisenberg's latest book is the story of the development of the new physics and its philosophical relation to earlier schemes of thought. Anyone not already familiar with the subject will find this historical discussion a thoroughly interesting account of human effort and achievement, as well as a concise summary of the crucial stages in the evolution of a new interpretation of nature. Even the professional reader will find much that is fresh and stimulating in the author's personal comments and point of view.

The central theme, of course, is the inadequacy of Newtonian mechanics to describe the new physical phenomena that became embarrassingly prominent about the turn of the century. Almost anyone would agree that the *necessity* for the theoretical departures that culminated in special relativity and quantum physics dates from the Michelson-Morley experiment and Hertz' discovery of the photoelectric effect. But Heisenberg regards relativity as the climax of a trend away from Newtonian mechanics that began with the electromagnetic field concept of Faraday and Maxwell; and he points out that the persistence of atomic structures through chemical reactions, unaccountable in terms of classical mechanics, foreshadowed the peculiar necessities of the quantum concepts.

In considering the relations among the four systems of physical concepts that he believes have attained their final form—Newtonian mechanics, thermodynamics, electrodynamics (including optics and special relativity), and quantum theory—Heisenberg notes that the first is a special case of the third or fourth, and that the second can be restated in terms of any of the other three. There remains the unreconciled contradiction between special relativity and quantum theory, growing out of their different implications with regard to the vexed question of action at a distance. Heisenberg suggests that this inconsistency eventually will be resolved within the framework of a more inclusive fifth set of concepts that probably will evolve from studies of the elementary particles.

Interesting as are the consequences of these radical developments for physics, their influence upon the broader assumptions of logic and philosophy are even more significant. Hardly an area of thought, from chemistry to theology, has escaped their impact. Even more than relativity, the quantum theory has required a painful readjustment of outlook—mainly because of the indeterminacy principle, which denies the idea of unique causality that had become dogma in physics. Heisenberg remarks, ". . . It would certainly have been still more difficult to understand quantum theory had not the success of the theory of relativity warned the physicists against the uncritical use of concepts taken from daily life or from classical physics."

The author stresses the fact that the indeterminacy principle cannot be comprehended in terms of a new arrangement of old concepts. It is unavoidably a mathematical formulation, because the verbal language that we have evolved to express ideas and relationships necessarily implies the intuitive, common-sense interpretations of nature that find their precise formulation in the differential equations of Newtonian dynamics. As an example of the inadequacy of the com-

SATELLITE ASTRONOMY
Slide Set 15

These slides are from official U. S. Government photographs.*

337 — Artist drawing of Vanguard rocket
338 — Satellite being readied for vibration test
339 — 6.4-inch sphere being fastened to third stage
340 — Test sphere mounted on third-stage rocket
341 — Nose cone being attached to 72-foot Vanguard
342 — Plastic model of Vanguard satellite
343 — Artist concept of satellite over southwest U. S.
344 — Drawing of preliminary schematic trajectory
345 — Trajectory being explained by Dr. John P. Hagan
346 — Gantry crane lifting second stage into position
347 — Prelaunching test at night in Florida
348 — Vanguard three-stage rocket assembly
349 — Dummy second and third stages in launching position
350 — Static test of launching vehicle
351 — Second Vanguard test-firing experiment
352 — Rocket leaves firing pad in third test
353 — Gantry crane moving away for satellite firing
354 — Vanguard starts into orbit, March 17, 1958
355 — Redstone missile being prepared for launching
356 — Redstone thunders into stratosphere
357 — Main stage of Jupiter C modified rocket
358 — Jupiter C second stage being hoisted from truck
359 — Explorer rocket main stage and nose
360 — Explorer high-speed assembly fitted into second-stage nose

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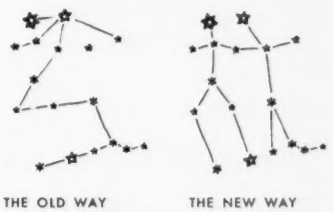

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Yet the stars in both diagrams are identical — check them!

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BOOKS AND THE SKY

PHYSICS AND PHILOSOPHY

Werner Heisenberg. Harper and Brothers, New York. 1958. 206 pages. $4.00.

NO DEVELOPMENTS in recent time have so shaken human complacency as have those in the physical sciences, through both their material consequences and their intellectual implications. This impact upon accepted modes of thought has been especially sharp in the past 60 years, with the advent of relativity and quantum physics and the consequent modification of the mechanistic interpretations that had dominated scientific thought. When a leader in these changes writes of the meaning and implications of his work, he is worth reading.

Much of Werner Heisenberg's latest book is the story of the development of the new physics and its philosophical relation to earlier schemes of thought. Anyone not already familiar with the subject will find this historical discussion a thoroughly interesting account of human effort and achievement, as well as a concise summary of the crucial stages in the evolution of a new interpretation of nature. Even the professional reader will find much that is fresh and stimulating in the author's personal comments and point of view.

The central theme, of course, is the inadequacy of Newtonian mechanics to describe the new physical phenomena that became embarrassingly prominent about the turn of the century. Almost anyone would agree that the *necessity* for the theoretical departures that culminated in special relativity and quantum physics dates from the Michelson-Morley experiment and Hertz' discovery of the photoelectric effect. But Heisenberg regards relativity as the climax of a trend away from Newtonian mechanics that began with the electromagnetic field concept of Faraday and Maxwell; and he points out that the persistence of atomic structures through chemical reactions, unaccountable in terms of classical mechanics, foreshadowed the peculiar necessities of the quantum concepts.

In considering the relations among the four systems of physical concepts that he believes have attained their final form—Newtonian mechanics, thermodynamics, electrodynamics (including optics and special relativity), and quantum theory—Heisenberg notes that the first is a special case of the third or fourth, and that the second can be restated in terms of any of the other three. There remains the unreconciled contradiction between special relativity and quantum theory, growing out of their different implications with regard to the vexed question of action at a distance. Heisenberg suggests that this inconsistency eventually will be resolved within the framework of a more inclusive fifth set of concepts that probably will evolve from studies of the elementary particles.

Interesting as are the consequences of these radical developments for physics, their influence upon the broader assumptions of logic and philosophy are even more significant. Hardly an area of thought, from chemistry to theology, has escaped their impact. Even more than relativity, the quantum theory has required a painful readjustment of outlook—mainly because of the indeterminacy principle, which denies the idea of unique causality that had become dogma in physics. Heisenberg remarks, ". . . It would certainly have been still more difficult to understand quantum theory had not the success of the theory of relativity warned the physicists against the uncritical use of concepts taken from daily life or from classical physics."

The author stresses the fact that the indeterminacy principle cannot be comprehended in terms of a new arrangement of old concepts. It is unavoidably a mathematical formulation, because the verbal language that we have evolved to express ideas and relationships necessarily implies the intuitive, common-sense interpretations of nature that find their precise formulation in the differential equations of Newtonian dynamics. As an example of the inadequacy of the com-

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mon language and the logic implicit in it, Heisenberg mentions the fundamental proposition of conventional logic that a meaningful statement is either true or not true. To accord with the probability concept of quantum physics, this exclusive principle must be modified by introducing a gradualistic concept that C. F. von Weizsäcker has termed "degree of truth."

Commenting on the fundamental implications of relativity and the quantum theory, Heisenberg notes that the controversy attending any basic revision of ideas in these cases reached an unprecedented degree of violence. Further, both problems have become connected with political issues, and some scientists have resorted to political methods to further their views. "This violent reaction on the recent developments of modern physics can only be understood when one realizes that here the foundations of physics have started moving; and that this motion has caused the feeling that the ground would be cut from science." He discusses in detail and with remarkable sympathy the sometimes intemperate criticisms of the new theories by Marxist critics, and examines the plight of the creative scientist who is caught between his specialized insights and the rather inflexible demands of his culture.

"Certainly it would be unwise to demand that the scientist should generally not be a loyal member of his community, that he should be deprived of the happiness that may come from belonging to a community, and it would be equally unwise to desire that the common ideas of society which from the scientific point of view are always simplifications should change instantaneously with the progress of scientific knowledge. . . . The scientist's first claim will always be intellectual honesty, while the community will frequently ask of the scientist that—in view of the variability of science—he at least wait a few decades before expressing in public his dissenting opinions. There is probably no simple solution to this problem, if tolerance alone is not sufficient. . . ."

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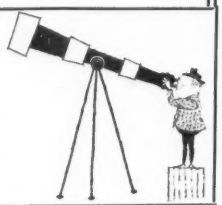

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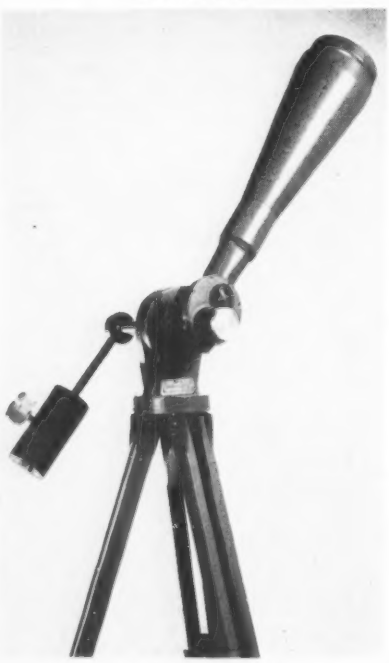

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THE EXPLORATION OF TIME

R. N. C. Bowen. Philosophical Library, Inc., New York, 1958. 143 pages. $6.00.

WHAT CONDITIONS prevailed on the earth during the long ages before the dawn of written history? This question has puzzled some of mankind's greatest thinkers, and only within the past century have concrete answers been forthcoming. In this book the author tells how we have learned the ages of the earth's oldest rocks, dated the ice ages, determined the position of man on the cosmic time-scale, and more.

This is the science of geochronology, which draws its techniques and data from anthropology, astronomy, botany, chemistry, climatology, geology, physics, and zoology. Evidently, the author has had to be brief, with only some 140 pages at his disposal. The opening section of 32 pages treats the earth as a planet, and here the brevity is painful; it is as if one were reading notes on file cards. More care in organizing the material, and closer attention to relevances, would have made this part more readable. Unfortunately, this criticism applies to some extent throughout the book.

Older ideas of time-scales are then treated. A century ago, Lord Kelvin thought the earth to be about 50 million years old, whereas we now make it almost as old as our universe — at least several billions of years.

Such historical notes lead naturally to a short discussion of the nature of time, a matter by no means simple. E. A. Milne has suggested a distinction between kinematic and dynamic time. A date of 1,500

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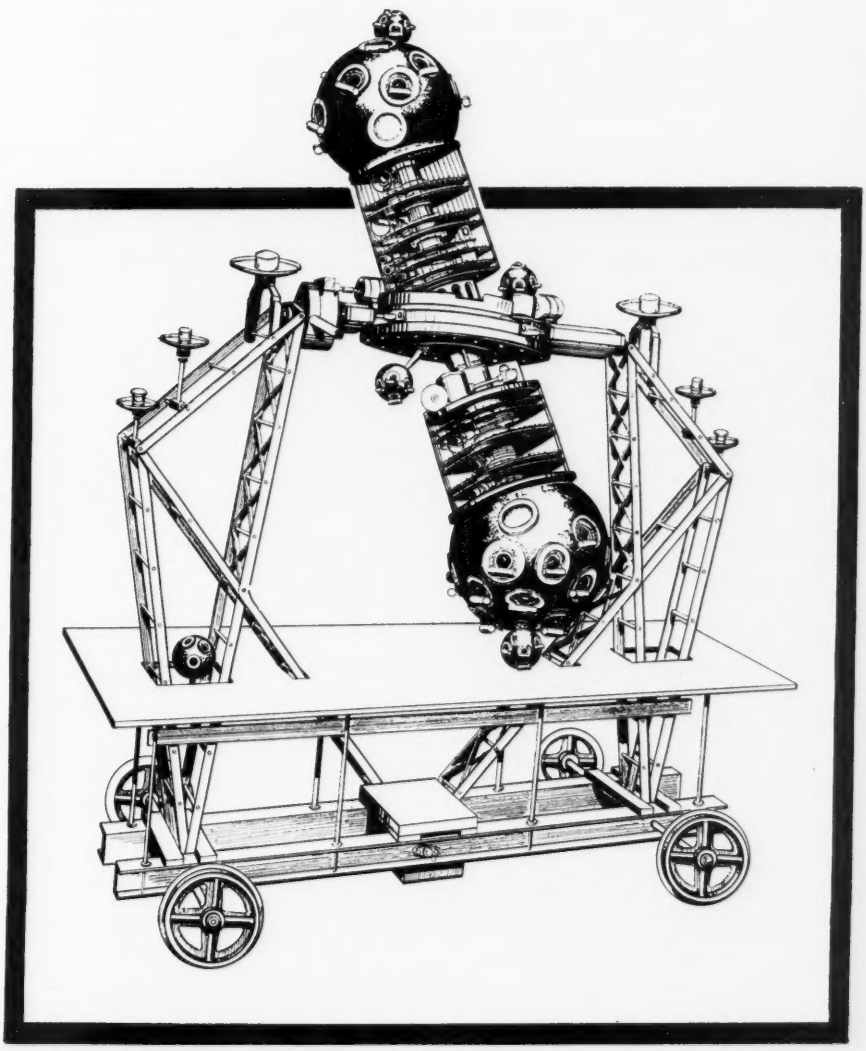

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million years on the first scale is 2,079 million on the second. The author believes that dynamic time is better suited for dating geologic facts, but his discussion of this problem is too short.

Physical and chemical methods of dating organic objects are taken up next, with illustrations of their application. In this category are measurements of fluorine, nitrogen, and uranium content. Perhaps the best-known method is radiocarbon dating, which carries us about 50,000 years in the past with reasonable accuracy. The remainder of this chapter is devoted to ways of determining the ages of rocks from their radioactivity.

A series of nine short chapters follows, beginning with astrophysical and astronomical methods of dating, and including those from the various sciences mentioned above. Two brief concluding chapters cover the evolution of man and the revolution in thought brought about by geochronology.

Written and printed in Great Britain, this book has some terms strange to American readers, such as "radium emanation" for "radon." The format is good, and the illustrations and tables of data profuse. The writing, however, is weak and the material poorly digested.

Nevertheless, as an introduction to a fascinating subject, and as a mine of information, this work is very valuable.

W. E. S.

ADVANCES IN GEOPHYSICS
Volume 5

H. E. Landsberg and **J. Van Mieghem,** editors. Academic Press, Inc., New York, 1958. 325 pages. $10.00.

ASTRONOMY and geophysics are sciences too closely interwoven to be conveniently separated. To an astronomer, the earth is the planet most accessible to investigation, from which many solar system problems can gain clarification. At the same time, an expert in the earth sciences finds in the moon and planets many analogues to his own problems. Many topics, such as tides, the shape of the earth, and ionospheric changes, belong equally to both sciences.

Astronomers who wish convenient and authoritative summaries of the present state of geophysical problems are well served by the series, *Advances in Geophysics,* which began in 1952.

Of the six contributions in the latest volume, three are of primary concern to astronomers. The Finnish geodesist R. A. Hirvonen has supplied a 23-page account of modern work on the size and shape of the earth. In recent years several very promising techniques have begun to be applied to the problem of interconnecting the triangulation networks of different continents. Dr. Hirvonen stresses the use of the moon as a triangulation point, the observations consisting of photoelectric

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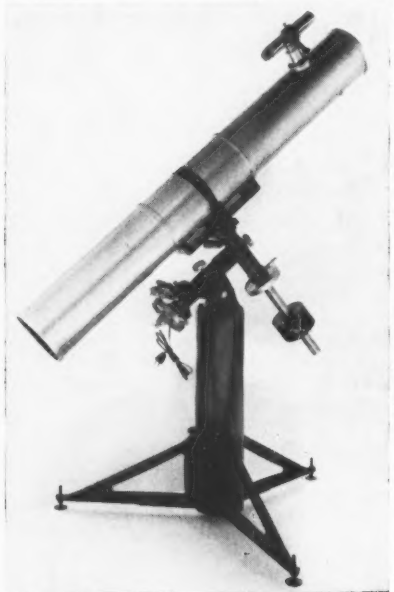

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timings of occultations of stars, and photographing the moon and background stars with the Markowitz moon camera.

The theory of oceanic tides has made notable advances in recent years, but many misconceptions have lingered in textbook accounts. A. T. Doodson, of the Liverpool Observatory and Tidal Institute, has sought to clarify some of these misunderstandings. His chapter contains a summary of mathematical studies of tides in idealized oceans, encircling the earth or bounded by meridians, and recent attempts to extend these results to actual oceans.

A central problem in solar-terrestrial relationships is the interaction of the sun's ultraviolet radiation with the earth's upper atmosphere. Its study has been greatly stimulated in the last few years by rocket measurements of solar ultraviolet light. The subject is comprehensively covered by K. Watanabe, now of the University of Hawaii. He presents a very useful collection of experimental data on the absorption of ultraviolet radiation by all important constituents of the terrestrial atmosphere. His chapter is of value to astronomers who are interested in the photochemistry of planetary atmospheres.

Other sections of the book deal with artificial modification of clouds to produce rain, and with microseisms, the small, rapid motions of the ground which, despite their name, are unrelated to earthquakes. Of more general interest is N. C. Gerson's historical account of the International Geophysical Year and its forerunners, the International Polar Years of 1882-3 and 1932-3. He offers some thoughtful criticism of the accumulation of enormous masses of observations, much of which may never be used. "It should be evident that the mere collection of data does not guarantee scientific advancement. Indeed, a patent example to the contrary is found in meteorology where the methods of Polar Front Analysis were developed by Norway primarily because of a dearth of reports from foreign countries during World War I."

This excellent collection of review articles is designed for the nonspecialist who has some familiarity with physics and mathematics, but several of the chapters are entirely nonmathematical. Each section has an extensive bibliography, running to 264 items in the case of Dr. Watanabe's article. There are cumulative indexes by title and by subject to the four earlier volumes in the series. This is an unusually well-edited book, in which the awkwardness often resulting from multiple authorship does not appear. J. A.

NEW BOOKS RECEIVED

THE AMERICAN EPHEMERIS AND NAUTICAL ALMANAC FOR THE YEAR 1960. *Nautical Almanac Office,* U. S. Naval Observatory, 1958, *U. S. Government Printing Office,* Washington 25, D. C. 533 pages. $4.00.

This standard reference work for astronomers has now been merged with the British *Nautical Almanac,* and the arrangement of its contents is considerably changed. As before, there are precise ephemerides for the sun, moon, planets, and the first four asteroids, but predictions are given to an additional decimal place for some of them. The detailed physical ephemerides of solar system bodies are indispensable to the serious amateur observer of the sun, moon, or planets. Occultation predictions have been omitted, as it is planned that they be published elsewhere.

L'EXPLORATION DES GALAXIES VOISINES, *Gerard de Vaucouleurs,* 1958, *Masson et Cie.,* 120 Blvd. St.-Germain, Paris 6, France. 153 pages. 1,600 fr, paper bound.

Observational data on the nature and structure of the nearby galaxies are analyzed by a leading French astronomer who is now on the staff of Harvard Observatory. Both optical and radio observations are discussed. The text is in French.

ROCKETS AND SATELLITES, *L. V. Berkner,* editor, 1958, *Pergamon.* 508 pages. $25.00.

Intended as a manual for scientific workers who are studying the environment of the earth by means of rockets and artificial satellites, this volume is a selection of technical writings, condensed and edited into a systematic whole. There are extended and amply illustrated accounts of the IGY satellite programs, instruments, and tracking procedures, including Russian plans. Much of this information is already out of date, and the preface was written November 1, 1957.

MOON TRIP, *William Nephew* and *Michael Chester,* 1958, *Putnam's.* 63 pages. $2.50.

The problems man faces in reaching the moon are well told for younger teen-age readers. A fictional trip is entertainingly set forth in easy-to-read type and illustrations.

AN ADVENTURE IN ASTRONOMY, *Kenneth Heuer,* 1958, *Viking.* 127 pages. $3.50.

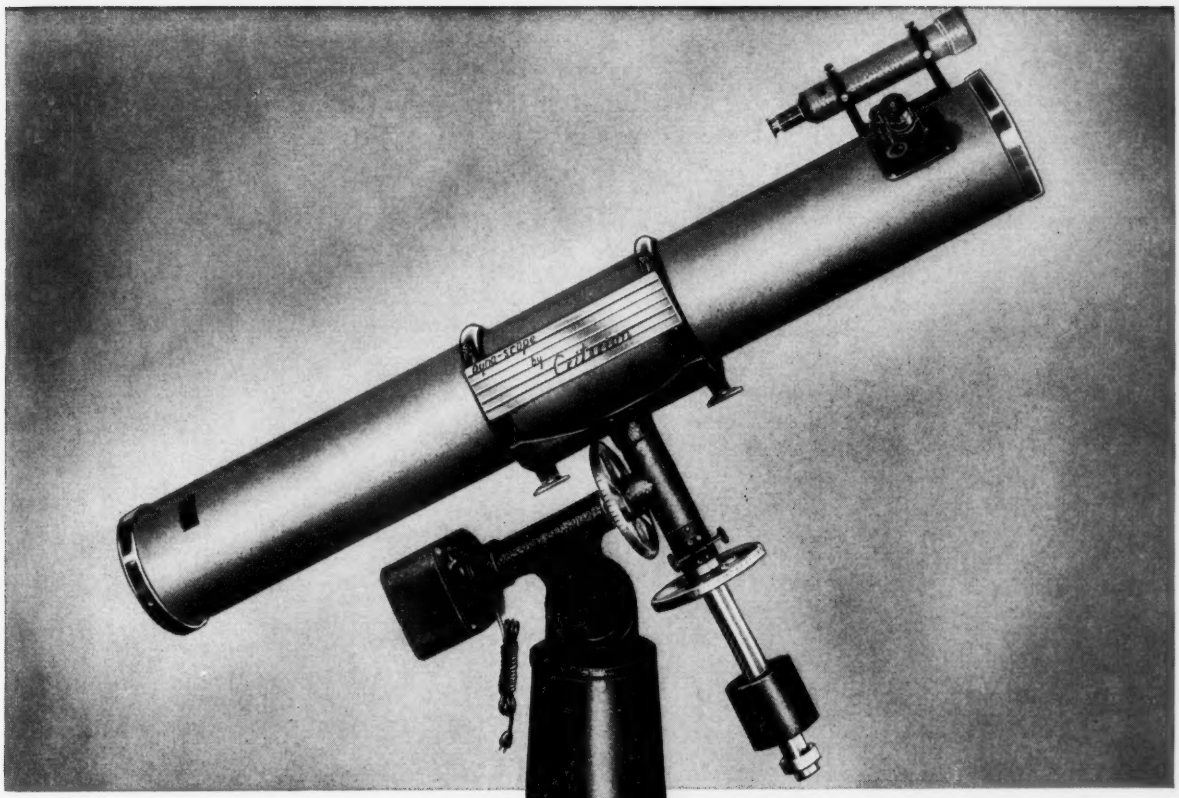
What the skygazer can see, and the apparent motions of the heavens, from seven different locations on the earth are described. These places (with their latitudes) are: New York City (+41°), Helsinki (+60°), Longyear City (+78°), the North Pole (+90°), the South Pole (−90°), Wellington (−41°), and Quito (0°).

THE FACE OF THE SUN, *H. W. Newton,* 1958, *Penguin Books,* 3300 Clipper Mill Rd., Baltimore 11, Md. 208 pages. 85 cents, paper bound.

A solar specialist recently retired from Greenwich Observatory provides a detailed account of the methods and results of observations of the sun. About half the book deals with sunspots; the remainder covers prominences and flares, radio emission, geomagnetic effects, and the aurora. The level is that of the mature amateur. There are many diagrams and other illustrations.

DICTIONARY OF ASTRONOMY AND ASTRONAUTICS, *Armand Spitz* and *Frank Gaynor,* 1959, *Philosophical Library.* 439 pages. $6.00.

More than 2,200 astronomical and astronautical terms are briefly defined for amateurs and laymen. As an indication of its scope, the three pages devoted to K explain the topics: K corona, K temperature, kamacite, Kapteyn selected areas, Kapteyn universe, Kellner eyepiece, Kepler's laws, Kepler's star, kiloparsec, kinetic energy, kinetic theory of gases, Kirchhoff's laws, Kirkwood gaps, and knot.



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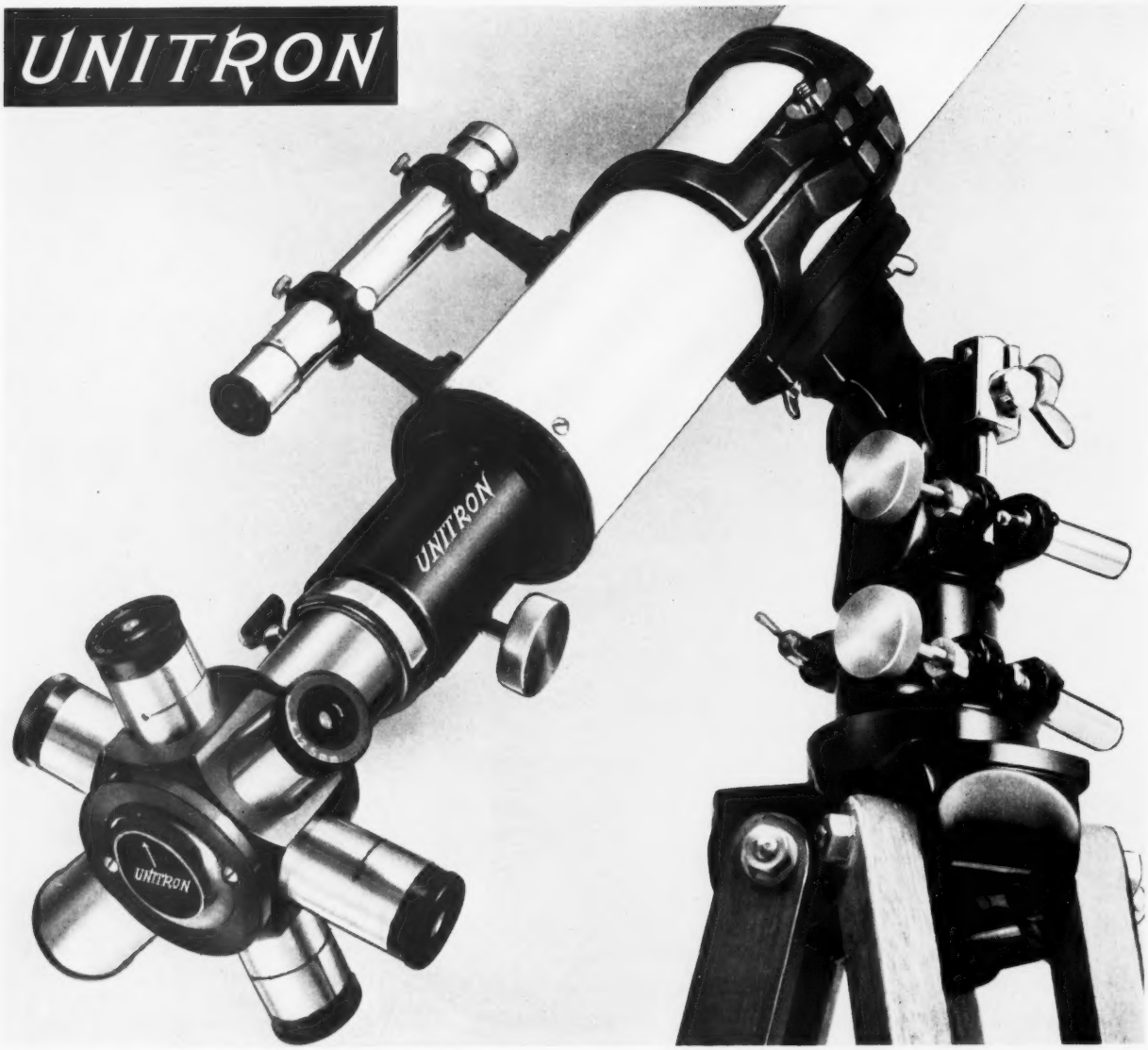

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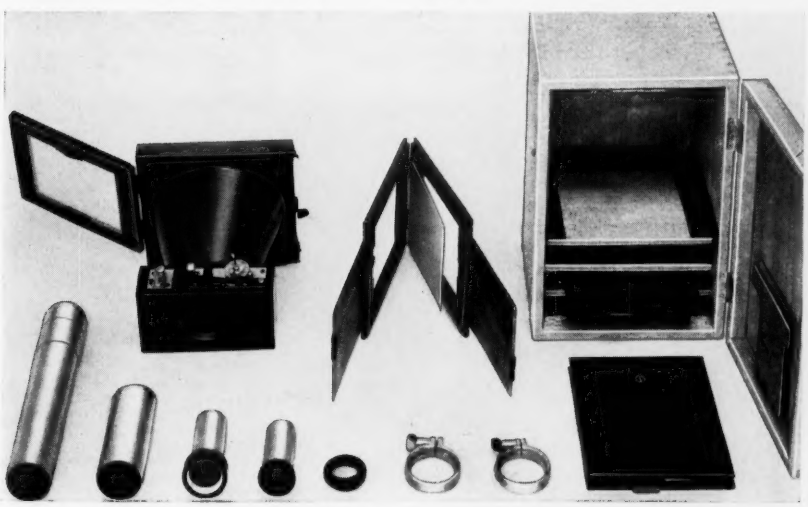

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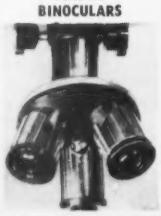

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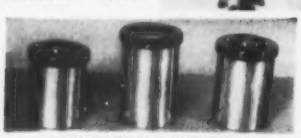

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Conventional methods were used to grind and polish the 4¼-inch pyrex primary mirror, and after rough grinding was completed the blank was perforated from the rear surface almost through to the front. Any changes in the glass caused by perforation occurred at that time, and after the mirror had been finished the hole was extended through with no change in figure. Many telescope makers use this system of perforating to retain a solid working surface, which can be pressed on a lap without fear of causing a zone.

When completed, the mirror was placed face down on a flat piece of plate glass and a 1/32" land was ground around the edge. This is the seating surface of the mirror and accounts for some of the ease with which this instrument can be aligned.

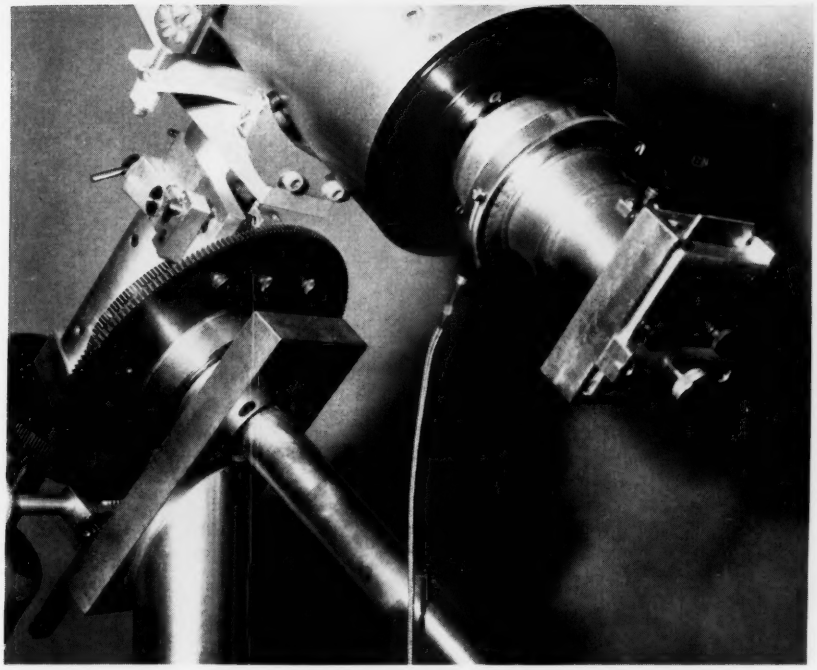
The correcting lens was made from Edmund's war-surplus slab 50119, the blank being biscuit-cut from the slab with a segmented-ring tool. The glass was pitched to a cake pan, which was then clamped to a drill-press table. At a speed of about 200 r.p.m., with 120 carborundum and water, the cutter was rapidly worked up and down, contacting the work for not more than a second at a time. Prolonged contact merely heats up the glass and might break it, and the frequent lifting of the cutter allows abrasive to flow to the edge of the blade. It took about two hours to cut through a slab 1-3/16" thick in this manner. The blank was round and the edge was square enough so edging was not necessary.

Surface grinding of the steep curves on the corrector was done on a vertical spindle at about 150 r.p.m. with cast-iron tools. Never again! This was one of the poorest ideas I have had in telescope making. Scratches, and the time spent keeping the tools in shape and to the proper radii, are enough to make me strongly recommend the glass-tool method for a single Maksutov lens. Doing it over again, I would saw out two blanks and use one for the tool, inverting whenever necessary to control curvature.

For those who have never worked optical glass before, I would like to emphasize that stock is removed four or five times faster than with pyrex, so proceed cautiously and check the radius of curvature very frequently.

For convenience in the checking operation, I used a depth micrometer mounted on a hardened base 2.8284" in diameter, as in the picture opposite. The radius of this base, $r = 1.4142$, is the square root of two, and simplifies the sagitta formula to $S = R - (R^2 - 2)^{\frac{1}{2}}$ (Sky and Telescope,

Carl E. Dahl at the eyepiece of his 4-inch Maksutov. The extension below the polar axle is a low-power telescope for aligning the mounting by means of the pole star, permitting the use of setting circles.



The special moon camera attached to the Dahl catadioptric telescope. Allen-head bolts hold the declination bearing to the worm wheel. A limited-action slow-motion device for declination is just above the top of the worm wheel.

February, 1957, page 187). While grinding, concentricity was checked continually with a 0.0005″ dial indicator and the special rig illustrated here.

For testing the figure while polishing, I used the system shown by Henry E. Paul on page 327 of *Amateur Telescope Making — Book Three*. An 8-mm. microscope objective projects an image of the pinhole, while a high-quality microscope cover glass forms a beam splitter enabling the worker to test exactly on the optical axis. The approximately 60-degree cone angle achieved by such a short-focus objective fully illuminates the lens surface in spite of its short radius of curvature, although it is still necessary to have the knife-edge well into your eyebrows to see a full image. While Foucault testing, don't forget that when viewing a convex surface from the rear a turned-down edge will appear turned up and vice versa.

The concave surface was polished with a full-size lap on the bottom. The convex side was worked with a subdiameter 3¼″ lap on top. Polishing in this manner can prove troublesome, as it is very easy to turn the edge because of the extreme curvature involved. Great care should be taken to prevent this, as surface corrections take a long time to make on such steep curves.

Beware of stress when mounting the shell on the concave side preparatory to

The standard jig in the left-hand picture was used to control wedge in the correcting lens. The 0.0005″ dial gauge measured the upper surface while the lens was rotated upon three convex metal posts, its edge being kept in contact with the two restraining pins. The depth gauge with special base, at the right, is in essence a ring spherometer used for controlling radius of curvature.

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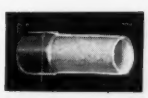

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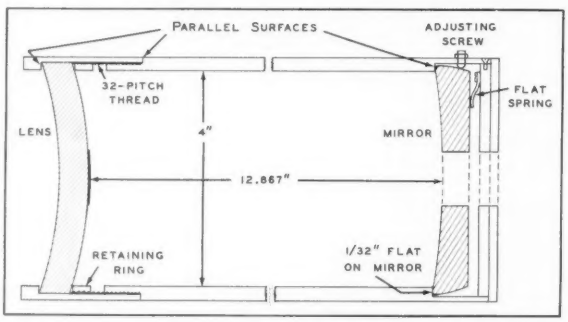
polishing the convex surface. My first corrector broke in two because I used a very hard pitch to hold an aluminum arbor to the glass. The aluminum expanded from the heat needed to melt the pitch and then contracted as it cooled. I heard a sharp click and that was the end of my first attempt, as the glass had fractured! My second lens was successfully mounted using a much softer pitch, tempered to the point where it just held the lens in place, and no further trouble was encountered.

The optical parts are mounted in heavy-walled aluminum tubing ¼" thick and 4" in inside diameter, as shown in the diagram. Careful lathe work made the alignment extremely simple. It is advisable to make a temporary setup of the lens and mirror to check that the focal plane is in the proper position and that all measurements for the tube have been correctly made. I found the image located inside the rear surface of the end cap, where it was impossible to reach with the eyepiece, so I had to shorten the spacing slightly.

The only adjustment on my telescope tube is at the primary mirror, which is held with three setscrews spaced 120 degrees apart to provide for placing it in a plane at right angles to the optical axis. In the absence of an optical flat to perform a final null test and align the primary, use an actual star image, adjusting the mirror position until the out-of-focus diffraction rings are perfectly round. Be careful not to crimp the mirror or astigmatism will result.

Obsolete parts and equipment were used to make the mounting. The bearings for the declination axle are bolted right to the worm gear, reducing the distance between the axes. The flat lever extending below the worm is a quick release to permit rapid motion of the instrument.



The unique tube design reduces the number of alignment points to just three adjusting screws, 120 degrees apart around the edge of the mirror. Behind the mirror, three flat springs similarly spaced keep the edge of the mirror's front surface in contact with the metal cell.

A special feature of the mounting provides for rapid alignment of the telescope on the North Star when it is set up for observing. In a system like that described by Dr. Paul on page 335 of the article mentioned above (also SKY AND TELESCOPE, June, 1956, page 370), an objective is placed in the hollow polar axle as part of a small telescope seen in the photographs. This arrangement requires a hole through the declination shaft, which in my instrument is only ¾" in diameter. A 1" or 1¼" shaft should have been used to avoid vibration at high powers.

All of the aluminum parts are anodized for protection against scuffing and oxidation, while the main tube is gold in color and the tube ends and setting circles black.

I enjoy photographing the moon with the camera attachment seen in the closeup picture of the mounting. The exposure control was made from the shutter of a large view camera. Short strips of 828 roll film are used in specially made filmholders. The unit is focused with a knife-edge that can be inserted directly in the film plane, the actual focusing being obtained with a null test on a star image. The diameter of the moon's image is nearly 1".

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Here is a combination of a Barlow and a particular ocular which gives outstanding results. It consists of our new Barlow and our 16.3-mm. (⅔" focal length) Erfle eyepiece. While the Barlow was not specifically designed to work with this eyepiece, it does so to an astonishing degree. All images are sharp and hard to the very edge of the field.

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Maksutov Telescope Notes

TWO YEARS have elapsed since the first article appeared here on building a Maksutov catadioptric telescope. While well over 100 of these instruments have been started, the task of construction is slow and difficult, and there have been few reports of completions.

Figuring Maksutov Telescopes. Some amateur telescope makers have questions on the Gregory-Maksutov telescope described in March, 1957, specifically on the f/15 design where the optics were all left spherical and no retouching was attempted. Although it is highly advisable finally to test such systems by autocollimation or collimated light, ray tracing has shown that the system is within the Rayleigh limit for permissible zonal spherical aberration if all the optics are *perfectly* spherical. Mr. Gregory comments:

"The formula for tolerable zonal aberration is given on page 138 of *Applied Optics and Optical Design* by A. E. Conrady. For an f/15 system of *any* aperture you must have no more than 0.112″ variation of the focus between the edge ray and the 0.707 zonal ray.

"The original f/15 design had differences between those two zones of 0.100″ in C (red) light and 0.083″ in F (blue) light, both well within the Rayleigh tolerance. On the revised f/15 figures, Sky and Telescope, June, 1958, page 423, the aberrations are even less, being 0.088″ for C light and 0.073″ for F light.

"Failure of instruments of the f/15 design to perform satisfactorily when not retouched is most likely due to the surfaces not being smooth or spherical enough. A Maksutov telescope is a task for an experienced worker, not a novice. Its construction should not be hurried if the excellent performance it is capable of is to be realized.

"The value of autocollimation in testing cannot be overemphasized. I have recently finished a 7½″ f/15 that, tested in this manner, revealed not a trace of spherochromatism. No trouble was had in securing a beautiful diffraction image with the light passing twice through the system."

Foucault-testing the Correcting Lens. Without auxiliary equipment, the eye cannot adequately cover the cone angle of the light beam from a Maksutov lens under test. A second trouble in testing the exceptionally steep surfaces is the astigmatism that results from the usual separation of the light source and knife-edge.

A beam splitter must be used in testing the lens, so that the returning beam and its source are exactly on axis. A high-quality microscope cover glass is often used by professional opticians.

Some consideration of the path of the returning beam of light reveals the requirements for an auxiliary optical system to enable visual examination of the image. With the f/15's cone angle of about 60

ONE-TWENTIETH WAVE PARABOLOIDAL MIRRORS

If the performance of your telescope has been disappointing in the past, I should like to suggest that now might be a good time to have any needed corrections made in the optical system, to the highest standards available. By so doing you may fully enjoy the coming spring and summer observing seasons.

I have had a sheet prepared, outlining the valid theoretical reasons for employing near-perfect optics for critical, high-magnification work, on the moon and planets, and I invite actual owners and users of telescopes, as well as persons considering the purchase of one, to ask for it, free of charge. In return I would **appreciate** a brief outline of your present instrument, including size, maker, construction, and performance on various celestial objects.

Although the "figuring" process on a 1/20-wave telescope mirror cannot be hurried, I am installing facilities which will enable somewhat earlier shipment to be made than has been true in the past. This is due to time-savings in the rougher parts of the work.

NEW 1/20-WAVE MIRRORS, f/5 to f/10, with diagonal
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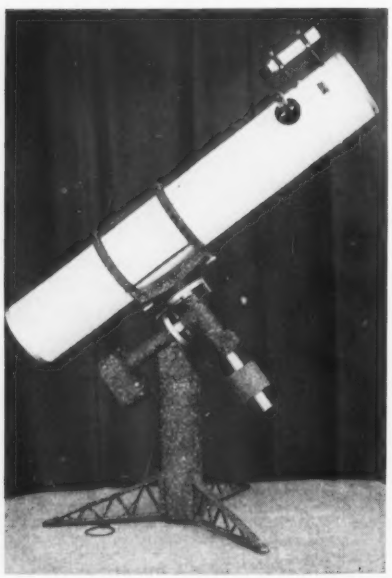
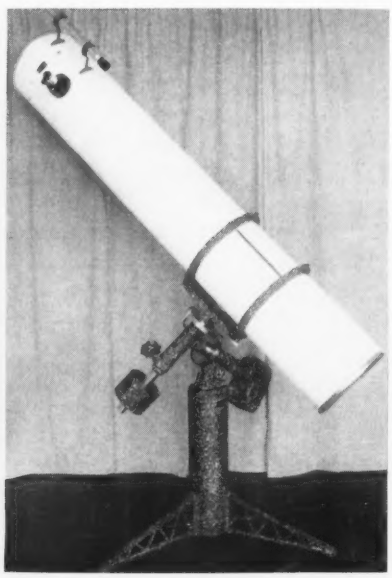
6-inch.....**$35.00** 8-inch.....**$50.00** 10-inch.....**$75.00**



New De Luxe Model "B" 8-inch ASTROLA, f/7, complete with rotating tube, clock drive, setting circles, and 3 oculars (85x, 210x, 360x). **$575**



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degrees, it will be necessary to use optics that have a working angle of at least this amount, such as Erfle eyepieces of 68-degree apparent field. Ordinary Ramsden eyepieces with an apparent field of 40 degrees will not do. Two giant Erfle 1¼-inch eyepieces, mounted field lens to field lens, make a satisfactory viewing system that acts as a one-power telescope. A 1¼-inch Erfle followed by a 1½-inch one does not operate as well.

If the eyepieces are of low power, they must be alike for optimum results. However, a 1¼-inch eyepiece can be employed behind a 16-mm. Erfle if the latter is placed next to the knife-edge. The writer has used this combination, obtaining a noticeable reduction in image size, and still covering the whole correcting lens of the f/15 system in the test.

The one drawback of such a testing unit is the strong distortion of the combined eyepieces, the edge of the field being contracted. A straight ruler viewed through the assembly appears strongly convex. This can be tolerated by marking the surface of the glass with a wax crayon to indicate every ¼", for example. While testing the surface, note the positions of any irregularities, especially near the edge, relative to the crayon marks, thus locating the exact positions of the areas to be corrected. Because of distortion, this viewing system does not work well with the Ronchi test; Foucault patterns are much easier to interpret.

Since the eyepiece combination forms an astronomical image of the mirror under test, the shadows will appear to move opposite to the actual motion of the knife-edge. Either this can be allowed for in interpreting the test, or the knife-edge can be mounted on the same side of the tester as the light source.

R. E. C.

OPTICAL SOCIETY MEETING

The spring meeting of the Optical Society of America will be held at the Hotel New Yorker in New York City, April 2-4. A panel discussion on Saturday, April 4th, will present reports on optics in the Soviet Union by recent visitors to that country. The sessions are open to the public.

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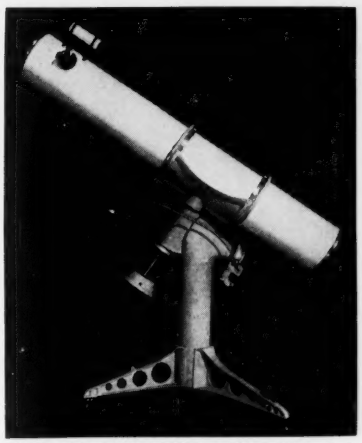

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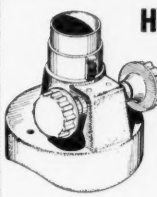

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If you wish, you can order this new 4-inch *Dynascope* without the *Dyn-o-matic* electric drive and add this feature later. All other features are exactly as specified. Note, however, that electric drive (Model No. ED-460) is $29.95 when purchased separately. You save $9.95 by ordering the complete *Dynascope*.

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- ***Classic 4-inch Parabolic Pyrex Mirror*** guaranteed to perform to Dawes' limit for its size. Aluminized and coated with zircon quartz.
- ***New Dyn-o-matic Electric Drive,*** totally enclosed, with self-acting clutch.
- ***Quick-Action Equatorial and Altazimuth Mount*** with fingertip control. A simple twist locks mount instantly or sets for any "drag" desired. Free-moving polar axis; adjustable for any latitude. Small setting circle for declination.
- ***4-Power Crosshair Finderscope.*** Crosshair, usually found only in much more expensive scopes, assures greater accuracy, easier spotting. Coated achromatic lenses. Screw-type micrometer focus. Extra large field of view. Double-posted bracket with collimation adjustments.
- ***Rack & Pinion Eyepiece Focusing.*** Assures smooth, precision focusing without lash or jerk.
- ***3 Compound Eyepieces:*** 18-mm Huygens, 9-mm Achromatic Ramsden, 7-mm Achromatic Ramsden for 65X, 130X and 167X. Completely threaded precision units with lenses that give clear, sharp views to extreme edges.
- ***Lifetime 45" Reinforced Bakelite Tube*** with reinforced ends and handsome brass trimmings. Fits snugly into fully contoured saddle. Attractive optical-black enamel finish.
- ***New Sturdy Steel Tubular Tripod*** designed to solve all stability problems. The result of hundreds of field tests and consultation with many authorities. Steadier support eliminates vibration. No canting, wobble or sideplay. Special position locks prevent collapse. Completely portable. Sets up instantly on uneven terrain. Folds up quickly, without disassembly, for full portability.

TAKE ANOTHER STEP FORWARD!

Score another "first" for Criterion's engineering genius! Never before has any American manufacturer offered a 4-inch *electrically driven* reflector of comparable quality for less than $200. Now you can enjoy this important extra-performance feature in any *Dynascope* you pick, with prices starting as low as $79.95!

Even at this unprecedented low price, not a single feature of earlier *Dynascopes* has been omitted. *Just the opposite!* These new 1959 models are also improved in other important ways . . . with new mounts, new tripods and other advances to increase your viewing pleasure. No wonder they are so enthusiastically recommended by so many outstanding authorities.

Whichever *Dynascope* you select, you are sure of top quality at its most reasonable cost, including the superb optical system for which Criterion is so famous. Every feature is precision finished to exacting professional standards. Every *Dynascope* is *twice-tested* to U.S. Government standards before shipment. And our Unconditional Guarantee means exactly what it says! Your *Dynascope must* live up to your expectations in every way or you may return it for full refund of the purchase price!

Select the new '59 *Dynascope* you prefer and send your check or money order today. Or use our liberal easy-payment plan and take months to pay. New *Dynascopes* are also available in 6", 8", 10" and 12" models. Write for full details about these exciting instruments and Criterion's full line of quality accessories.

OR TAKE YOUR CHOICE OF THESE OTHER NEW 1959 MODELS!

NEW! SUPER DELUXE ELECTRIC 4-INCH DYNASCOPE

with features formerly found only in the finest reflector telescopes!

For those who want the ultimate in an electric-driven 4-inch reflector! This top-performing new *DYNASCOPE* is actually a 4-inch duplicate of our DeLuxe 6-inch model. You get such truly professional features as a 6 x 30 achromatic finderscope, a *fully rotating* tube for more comfortable viewing and a superb optical system that includes five of our finest eyepieces—four achromatic and one orthoscopic. You won't find a finer 4-inch reflector anywhere!

• HANDSOME STEEL AND GRAINED-HARDWOOD TRIPOD with special tapered shank ends. Includes spreaders and heavily reinforced joints. No danger of collapse, sideplay or wobble. Sets up quickly anywhere; folds easily and compactly for complete portability.

• EXQUISITE HAND-CORRECTED 4-INCH PARABOLIC MIRROR accurate to better than 1/8 wave. Made of pyrex. Aluminized, overcoated. Triple tested. Mounted in removable cell.

• ADVANCED DESIGN EXTRA HEAVY-DUTY EQUATORIAL MOUNT with oversize castings and fingertip control. Adjustable for latitude. Absolutely smooth action. Rotating base for easier orientation. • SETTING CIRCLES for both right ascension and declination assure faster location of specific object. • SLOW MOTION on declination. • 5 SHARP-VIEW EYEPIECES: 18-mm Achromatic Ramsden, 12.7-mm Achromatic Ramsden, 9-mm Achromatic Ramsden, 7-mm Achromatic Ramsden and 6-mm Orthoscopic—for 65X, 100X, 130X, 167X and 220X. All precision threaded, standard 1¼" diameter barrels. • NEW DYN-O-MATIC ELECTRIC DRIVE, with totally enclosed self-acting clutch. • 6 X 30 ACHROMATIC FINDERSCOPE with cross hairs and extra-firm twin post mounting. Micrometer focusing, coated achromatic objective. • FULLY ROTATING BAKELITE TUBE with double-thick wall for maximum strength. Polished rings of pure cast aluminum provide extra reinforcement for ends. Smart grey wrinkle finish.

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NEW! DELUXE ELECTRIC 4-INCH DYNASCOPE

with heavy-duty mount and new Rotating Rings

A truly scientific instrument with all the features of our standard model plus extra advantages for even finer viewing. Larger and heavier mount (weighs over 12 lbs.) is full equatorial. Saddle has felt-lined rotating rings that permit tube to be quickly positioned for accessories or to bring eyepiece into more comfortable viewing position.

• EXQUISITE 4-INCH PARABOLIC PYREX MIRROR accurate to 1/8 wave. For famed Dynascope optical superiority. • NEW DYN-O-MATIC ELECTRIC DRIVE, totally enclosed, with self-acting clutch. • TRUE EQUATORIAL AND ALTAZIMUTH MOUNT with complete friction adjustments for any latitude, declination and ascension. Rugged cast-iron construction. • 3 STANDARD 1¼" EYEPIECES: 18-mm Huygens, 9-mm Achromatic Ramsden, 7-mm Achromatic Ramsden for 65X, 130X and 167X. • 4X ACHROMATIC FINDERSCOPE with crosshairs, micrometer focusing and adjustable collimation. • RACK AND PINION DOUBLE-DRAW EYEPIECE Holder for easy, exact adjustments. Accommodates any eyepiece, negative or positive. • PROFESSIONAL-TYPE STEEL TRIPOD with fast-fold legs for easy portability. Extra stability in vibration-free design.

Model No. K-2A
COMPLETE FOR ONLY
$109.95
F.O.B. Hartford. Shippg. Wt. 33 lbs. Exp. Chgs. Col.
Available without Electric Drive for $89.95

NEW! LIGHTWEIGHT ELECTRIC 6-INCH DYNASCOPE

With Setting Circles—New Addition to the DYNASCOPE Line!

Here is *6-inch* perfomance at a *4-inch* price! This scientifically designed new Dynascope offers all the essential features for superior viewing at a cost within the reach of any serious amateur. Constructed of lifetime materials and engineered for maximum stability, yet is extremely light. And look at these other quality features in this exciting new instrument:

• f/8 6-INCH PARABOLIC MIRROR accurate to 1/8 wave. Ground and polished to exacting specifications. Aluminized by vacuum-chamber process. Protected with layer of zircon quartz. • NEW DYN-O-MATIC ELECTRIC DRIVE, totally enclosed, with self-acting clutch. • 3 MATCHED EYEPIECES – 75x, 150x, 343x. Powers can be tripled with Goodwin Barlow, other sizes available. • 6 X 30 CROSSHAIR FINDERSCOPE. Fully Achromatic, with micrometer focusing. • HEAVY-DUTY MOUNT with setting circles • RACK-AND-PINION EYEPIECE HOLDER for smooth, accurate focusing. • ROTATING TUBE for more comfortable viewing. • STRONG LIGHTWEIGHT TRIPOD for sure, steady support.

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CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

OCCULTATION PREDICTIONS

March 20-21 **Alpha Cancri** 4.3, 8:56.2 +12-01.1, 12. Im: **C** 7:43.9 −0.7 +0.4 46; **E** 7:31.6 −1.1 −0.4 61; **F** 7:31.7 −1.0 −1.1 94; **H** 6:55.6 −1.6 −1.4 109; **I** 6:39.0 −1.8 −0.2 76.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo,** lat. **L**) within 200 or 300 miles of a standard station (long. **LoS,** lat. **LS**). Multiply **a** by the difference in longitude (**Lo**−**LoS**), and multiply **b** by the difference in latitude (**L**−**LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

MINIMA OF ALGOL

March 2, 0:03; 4, 20:52; 7, 17:41; 10, 14:31; 13, 11:20; 16, 8:09; 19, 4:59; 22, 1:48; 24, 22:37; 27, 19:26; 30, 16:15.

April 2, 13:04; 5, 9:54; 8, 6:43.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

MINOR PLANET PREDICTIONS

Eleonora, 354, 9.5. March 3, 12:54.6 +13-22; 13, 12:49.9 +15-31; 23, 12:43.5 +17-31. April 2, 12:36.3 +19-11; 12, 12:29.3 +20-21; 22, 12:23.6 +21-02. Opposition on March 31.

Euterpe, 27, 9.8. March 13, 13:06.6 −4-13; 23, 12:58.3 −3-17. April 2, 12:48.8 −2-16; 12, 12:39.3 −1-19; 22, 12:31.1 −0-34. May 2, 12:25.1 −0-04. Opposition on April 3.

Juno, 3, 9.6. March 13, 13:36.3 −2-17; 23, 13:30.3 −0-57. April 2, 13:23.0 +0-26; 12, 13:15.1 +1-45; 22, 13:07.4 +2-54. May 2, 13:00.7 +3-49. Opposition on April 11.

Irene, 14, 8.7. March 23, 13:57.4 +4-19. April 2, 13:50.7 +5-07; 12, 13:42.3 +5-44; 22, 13:33.3 +6-03. May 2, 13:25.3 +5-59; 12, 13:19.0 +5-28. Opposition on April 17.

Pallas, 2, 7.6. March 23, 13:56.7 +12-07. April 2, 13:50.6 +15-29; 12, 13:43.3 +18-27; 22, 13:35.6 +20-49. May 2, 13:28.7 +22-29; 12, 13:23.3 +23-28. Opposition on April 17.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

VARIABLE STAR MAXIMA

March 3, T Normae, 153654, 7.4; 6, T Centauri, 133633, 6.1; 7, S Pictoris, 050848, 8.0; 8, R Normae, 152849, 7.2; 23, R Serpentis, 154615, 6.8; 23, V Canum Venaticorum, 131546, 7.1; 24, RV Sagittarii, 182133, 7.8; 27, S Pegasi, 231508, 8.0.

April 1, R Virginis, 123307, 6.9; 3, RS Librae, 151822, 7.7; 5, X Centauri, 114441, 7.8; 6, R Cancri, 081112, 6.8.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

MOON PHASES AND DISTANCE

Last quarter	March	2, 2:54
New moon	March	9, 10:51
First quarter	March	17, 15:10
Full moon	March	24, 20:02
Last quarter	March	31, 11:06

	March	Distance	Diameter
Apogee	14, 9h	251,800 mi.	29′ 29″
Perigee	26, 9h	224,100 mi.	33′ 08″
	April		
Apogee	10, 23h	252,400 mi.	29′ 25″

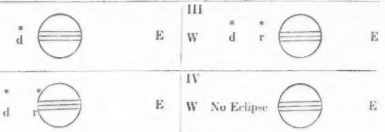
JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

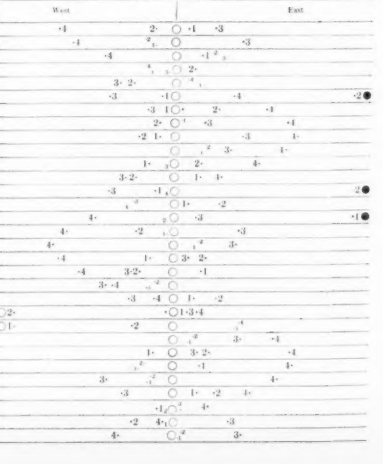
In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac.*

MARCH

Phases of the Eclipses of the Satellites



Configurations at 0h 15m



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FINE ANASTIGMAT Lenses! Barrel, iris: 350-mm. f/5.6, $39.50; 500-mm. f/6.3, $57.50; 750-mm. f/6.3, $75.00. Walter Baer, 741 State St., Lancaster 2, Pa.

FREE! 72-page photographic bargain catalogue. Thousands of new and used bargains, photographic equipment and supplies. Write Dept. 26-B2, Central Camera Co., 230 S. Wabash Ave., Chicago 4, Ill.

INTERESTED in astronomy as a career? *Vocational and Professional Monographs: Astronomy,* by Dr. Freeman D. Miller, describes personal qualifications, scholastic training, and job opportunities. $1.00 postpaid. Send to Box B, *Sky and Telescope,* Harvard Observatory, Cambridge 38, Mass.

SIDEREAL DRIVE for telescope, camera, track stars accurately, simple gearless design, plans, $1.00. "Space Chart," planets, sun, moon, asteroids, constellation maps, $1.00. L. Mussgnug, Box 74, Bethel, Conn.

TELESCOPE TUBING: Aluminum, 2″ through 8″ diameter, any length. Pesco-A, Box 365, Ann Arbor, Mich.

3″ UNITRON equatorial outfit, like new, $345.00. J. E. Finlay, 1133 Pleasant St., Bridgewater, Mass.

PORTABLE, metal, 6″ equatorial reflector. Rack-and-pinion focusing, 6x finder, aluminum tube, rust-proof mounting. Sacrifice, $125.00. Donald Trombino, N.J.A.S., 4-4 D Alabama Ave., Paterson 3, N. J.

4″ UNITRON equatorial, perfect, extras, sacrifice. L. L. Hall, 7101 Knowlton Pl., Los Angeles 45, Calif.

SPACE CLOCK: Tells the time from the stars, also computes latitude and longitude. Simple to understand. Price, $1.00. Horner-Cooley Productions, Inc., 6112 Selma Ave., Hollywood 28, Calif.

BEGINNER'S Telescope Kit: $3.00 each, all parts, and 3 lenses. Make 8-power astronomical refractor. Perfect for youngsters and school projects. Frank Myers, 19200 N. Park Blvd., Shaker Heights, Ohio.

WANTED: 2.4″ or 3″ Unitron. H. Cline, 15 Hughes Pl., Summit, N. J.

FINEST TELESCOPES, mounts, accessories at reasonable prices. New catalogue. Vernonscope and Co., Candor, N. Y.

SUPPLIES for amateur rocket research. Catalogue with safety tips and illustrated plans, 25¢ (refundable). Central Rocket Co., Box 89, Waupaca, Wisc.

WANTED: Questar, used. Will pay cash. Neil McDade, 910 Avon Pl., Chattanooga 5, Tenn.

NOTICE: Local firm considering entrance into optical field wishes to offer complete line of refracting telescopes from 1.6″ to 12″ aperture. Prices range from $13.95 to $15,000.00. All accessories for reflecting and refracting telescopes available. Please state specific requirements. Only interested persons need inquire. Duane-Westfield Mfg. Co., P. O. Box 2643, Akron 1, Ohio.

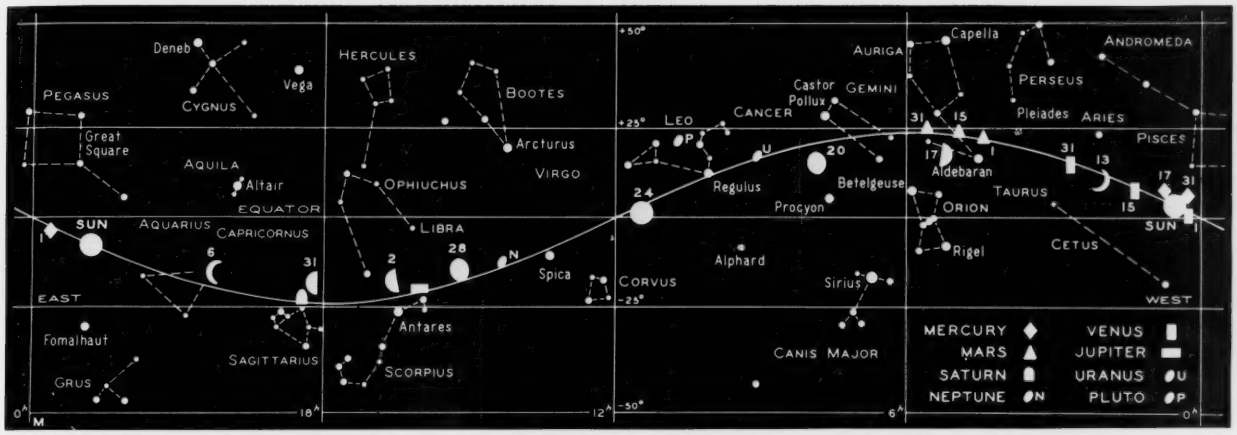
ZEISS 12 x 60 antiaircraft coated binoculars, $90.00. Mounted pair of 60-mm. 18¼″-focal-length lenses, $25.00. Ross 5″ f/4 aerial lens, $15.00. Bushnell 7 x 35 Rangemaster, $80.00. Eugene Zartarian, 317 Spencer Pl., Paramus, N. J.

"SATELLITE PATHFINDER," an ingenious device designed at the American Museum-Hayden Planetarium to help predict Northern Hemisphere passages of artificial satellites. $1.95 postpaid. Send to Box C, *Sky and Telescope,* Harvard Observatory, Cambridge 38, Mass.

1958 UNITRON 2.4″ altazimuth, standard accessories, $85.00 f.o.b. M. Downey, 907 E. River St., El Paso, Tex.

CROSSLINES: Made to order. Metal or super-fine quartz fiber. $3.00 and up. Premier Reticles, Sky Dept., Silver Spring, Md.

SOUTHWESTERN OBSERVERS: Finest refractor telescopes and accessories shipped from Dallas, Texas. Models, terms, complete information on request. Melton Industries, 1901 Levee St., Dallas 7, Tex. Tel.: RI 8-4769.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other days shown. All positions are for 0h Universal time on the respective dates.

Mercury reaches greatest eastern elongation on March 12th, 18° 20′ from the sun, when it can be seen in the west during evening twilight, setting about 1½ hours after the sun. This is a relatively favorable elongation, and the planet should be visible for about 10 days before and after this date.

On the 12th, Mercury is of magnitude −0.1, and its 7″.2-diameter disk is almost half illuminated. Inferior conjunction with the sun will occur on March 29th. The moon will be only about 1° south of Mercury on the early evening of the 10th — aiding in locating this planet.

Venus is a brilliant evening object in the west, by midmonth setting about 2½ hours after the sun. Then at magnitude −3.4, the planet appears in a telescope as a small gibbous disk, 12″ in diameter and 87-per-cent illuminated. The crescent moon will be very close to Venus just after sunset on the 11th, when an occultation of the planet will be visible in Central and South America.

Earth arrives at heliocentric longitude 180° on March 21st at 8:55 Universal time, when spring begins in the Northern Hemisphere, autumn in the Southern.

The moon will be partially eclipsed on March 24th for observers in Australia, Asia, Africa, Europe, and Antarctica. At mideclipse 26.9 per cent of the moon's diameter will be immersed in the umbra of the earth's shadow.

Mars at midmonth is in Taurus, crossing the meridian half an hour before sunset and setting about an hour after midnight, local time. As the red planet's distance from the earth increases, it will have faded to magnitude +1.1 by the 15th, with its telescopic disk only 6″.6 in diameter.

Jupiter rises about half an hour before local midnight on March 15th, and can be seen as a brilliant golden object of magnitude −1.8 near the Libra-Scorpius border. The giant planet will be stationary in right ascension on the 19th, beginning retrograde (westward) motion among the stars. Jupiter will be 3° south of the moon on the morning of March 1st.

Saturn is at western quadrature on the 28th, rising about 1:30 a.m., local time, and being visible in Sagittarius as an object of magnitude +0.8.

Uranus, in Cancer, is well placed for evening observations in field glasses, as this 6th-magnitude planet crosses the meridian about 9:30 p.m., local time, in midmonth. Its right ascension and declination on the 15th are 9h 01m.3, +17° 39′ (1950); these co-ordinates are changing by −0m.1, +0′.5 per day.

Neptune is near the Virgo-Libra border, at 14h 19m.0, −12° 00′, on March 15th. This 8th-magnitude object rises about two hours before midnight, and is readily observable in small telescopes or in binoculars.

W. H. G.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

SKYSCOPE

A 3½″-diameter, reflecting astronomical telescope 100% American made. Completely mounted. Used by schools and universities for over 18 years. Unconditionally guaranteed.

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(Includes heavy, unbreakable tripod and a 60-power eyepiece)

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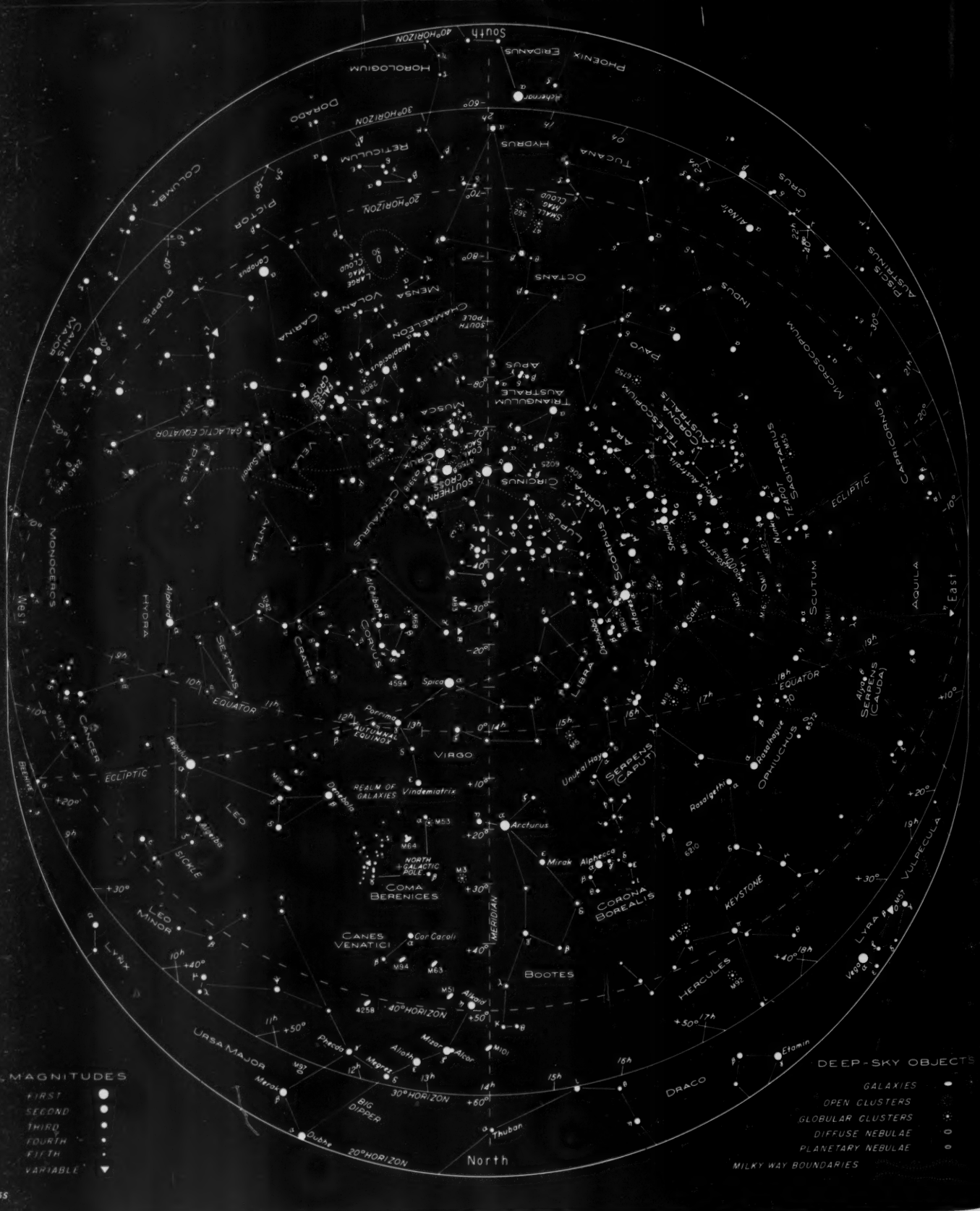
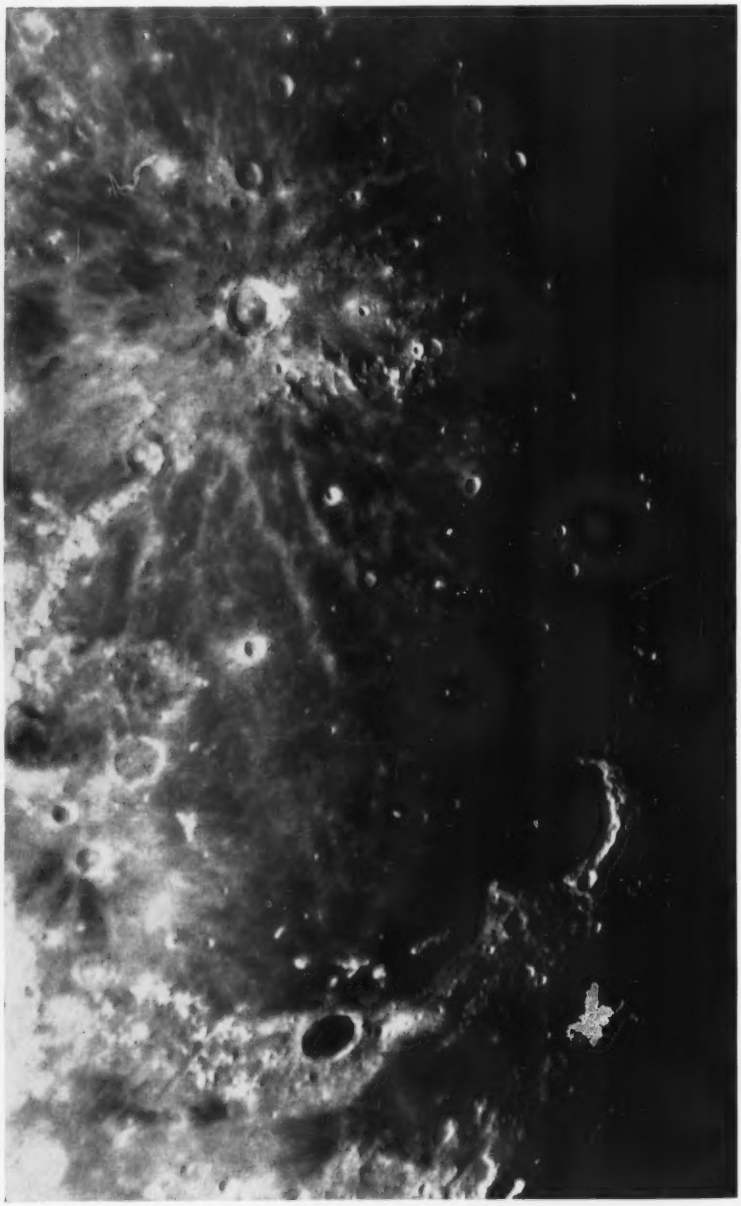

South
40° HORIZON
30° HORIZON
20° HORIZON
HORIZON
PHOENIX
ERIDANUS
HOROLOGIUM
DORADO
RETICULUM
HYDRUS
TUCANA
GRUS
PISCIS AUSTRINUS
COLUMBA
PICTOR
PUPPIS
CANIS MAJOR
VOLANS
MENSA
CHAMAELEON
OCTANS
INDUS
PAVO
MICROSCOPIUM
CAPRICORNUS
APUS
TRIANGULUM AUSTRALE
MUSCA
CORONA AUSTRALIS
TELESCOPIUM
ARA
CIRCINUS
NORMA
LUPUS
CENTAURUS
CRUX
SOUTHERN CROSS
GALACTIC EQUATOR
VELA
ANTLIA
MONOCEROS
HYDRA
CORVUS
CRATER
SEXTANS
CANCER
LEO
LEO MINOR
SICKLE
LYNX
URSA MAJOR
BIG DIPPER
CANES VENATICI
COMA BERENICES
BOOTES
CORONA BOREALIS
HERCULES
KEYSTONE
LYRA
VULPECULA
DRACO
OPHIUCHUS
SERPENS (CAUDA)
SERPENS (CAPUT)
SCORPIUS
SCUTUM
AQUILA
SAGITTARIUS
TEAPOT
LIBRA
VIRGO
ECLIPTIC
EQUATOR
AUTUMNAL EQUINOX
MERIDIAN
REALM OF GALAXIES
NORTH GALACTIC POLE
SOUTH POLE
LARGE MAGELLANIC CLOUD
SMALL MAGELLANIC CLOUD
Canopus
Achernar
Alpheratz
Algenib
Alphard
Regulus
Denebola
Algieba
Porrima
Spica
Arcturus
Vindemiatrix
Unukalhai
Rasalgethi
Rasalhague
Alphecca
Mirak
Alkaid
Mizar
Alcor
Phecda
Megrez
Alioth
Merak
Dubhe
Thuban
Etamin
Kochab
Antares
Shaula
Sargas
Nunki
Ascella
Kaus Australis
Kaus Media
Kaus Borealis
Sabik
Alphard
Alphekka
Gienah
Algorab
Acrux
Mimosa
Hadar
Rigil Kentaurus
Toliman
Miaplacidus
Suhail
Avior
Aspidiske
Alphard
Alphekka
Alkaid
Mirak
Alpheratz
Algenib
Achernar
Canopus
Rigil Kentaurus
Toliman
Hadar
Mimosa
Acrux
Gacrux

STARS FOR MARCH

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of March, respectively; also, at 7 p.m. on April 7th. For other dates, add or subtract ½ hour per week.

Gemini has just crossed the meridian at chart time, and its two brightest stars, Castor and Pollux, are high in the southern sky. First-magnitude Procyon, in Canis Minor, is farther south. Cancer is well placed for observing; look for the misty Beehive cluster there.

QUESTAR NEWS • *March, 1959*



As we said last month, lunar detail is best seen and photographed near the terminator, which is here the line of sunrise, the great curve of shadow on the right. Note how the finest detail lies adjacent to this boundary of lunar night. This is the region of long shadows and brilliantly illuminated cliffs and ramparts. Here, too, wrinkles in the lunar plain show up well, as at upper right. By contrast, everything upon the left looks pale and out of focus, where the higher angle of the falling sunlight gives to each feature a shorter shadow. Then, too, up to 1,000 times as much light can fall on this side of a negative, causing overexposure of the area, with attendant difficulties.

In studying the print, we were amazed at its sharpness and resolution, and publish it knowing full well that the very smallest details will not survive the engraver's dots. This shot embraces half the moon's diameter. Exposure, 15 seconds on slow, fine-grain, contrasty Microfile 35-mm. film in Hexacon camera.

This is another picture by Mr. and Mrs. Ralph Davis, who say nobody else has ever had so much fun with a Questar or given one so many lifetimes of use. "A big factor in our favor," says Mr. Davis, "is the steadiness of Questar's drive and images. We still do best with fine-grain film and long exposures."

Have you ever seen such beautiful work done with only 3.5 inches of aperture? We never have. This fact alone is astonishing enough, but when you consider the tiny size of Questar (it can be hidden by this page) and its weight of only 7 pounds — well, the whole thing often seems to us preposterous. Downright impertinent, in view of some installations. And right here, if we say Questar costs $995, can be had on time also, and our literature will tell you all about it — voila! the commercial.

The Albright Gallery in Buffalo has invited us to put Questar into a major exhibition entitled "20th Century Design: U.S.A." It will open at the Albright in April and be shown during 1959-60 at cosponsoring art museums in Cleveland, St. Louis, Minneapolis, San Francisco, Dallas, Portland and Dayton.

We hear by the most roundabout way imaginable that the staff of Mount Stromlo Observatory in Australia finds Dr. Bart J. Bok's Questar amazing in a wholly unexpected way — its use terrestrially. You see, as we tell you, everybody is surprised at how much fun it is to look around in daylight!

How lack of sharpness can be caused by a weak film pressure plate in 35-mm. cameras is an interesting technical topic discussed in "Camera 35" No. 1, 1959. The author, Arthur Kramer, describes how his single-lens reflex camera took fuzzy pictures because a weak pressure plate was permitting the film to move during the time of exposure.

No sooner was the above written than a letter from R. Douglas Smith, of South Pasadena, California, arrived, saying to tell Arthur Clarke this is probably the trouble with his Exakta.

"Life" magazine called us on the last day of the year to say that Dr. Strong's balloon ascent to photograph Mars with a whopping big telescope from nearly 20 miles up had been called off. For some two months a "Life" man with a Questar-equipped movie camera had been standing by to photograph this most exciting event. To us, old-time Mars fans that we are, this was dismal news, and we can imagine the disappointment of the people concerned.

We don't know about you, but we've read everything we could on Mars for nearly 40 years, and during all that time the great questions have remained unanswered. How many times we've said to ourselves that before we kick off we'd really like to know about the kind of life that looks so marvelously green and living through the telescope — is it or isn't it? We have grown awfully used to living with these questions year in and year out.

A fellow was showing us his fancy cacti and succulents. Very sophisticated plants, these, he says, no simple form of life. And we were struck with one that we intuitively knew could live on chilly, dusty Mars. There it was, an inch and a half long, growing upward as bananas really do, in clusters, but each curved pod-like entity, so help us, pointing toward the sky a blunt end that was a clear transparent lens. This one could make it, we thought, as we strove to slice it lengthwise and its tough integument defied our knife. Sure enough, inside the plant (its very name escapes us) immersed in clearest juice were bright green cells most excellently arranged to best receive the focused light.

Thus, over the years, we have mused serenely on the mysteries of our sister planets. We recall, too, not so many years ago, the time Walter Haas diffidently asked us to photograph a Mercator's projection of Mars for the previous year, to send to the few lonely observers who had bothered to keep in touch during the war. Someone had to do it, he said, now that W. H. Pickering was gone, so he had done it. Only a slender handful cared that barren year, and Mars was mighty far away.

All at once there is this rumbling and roaring, this taking off from launching pads. We were prepared, oh yes. No surprise to us, no sir! It had to happen — been following it for years. But you know, now that it is just around the corner, next month, next year, almost any time now — we just cannot cope with the idea. In theory, yes. But that soon one man may walk upon the moon while another paces Mars — this is too much, this is what we find really hard to comprehend, encompass mentally. We hope that you have better luck than we in adjusting to this new fantastic dawn of history.

Laurence Braymer
President

QUESTAR CORPORATION
New Hope, Pennsylvania

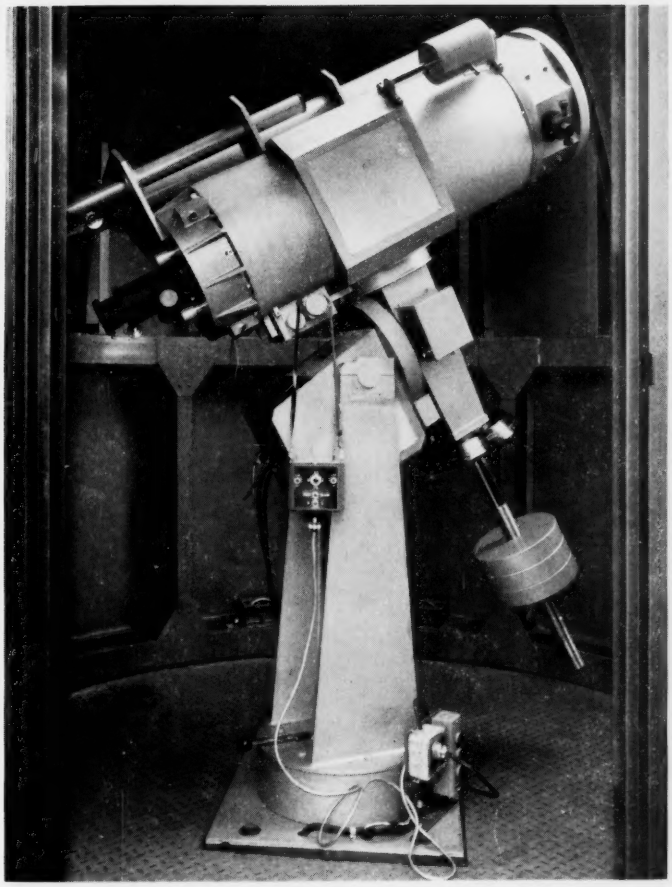
A Complete Private Observatory

Telescope by TINSLEY

Housing by ASTRO-DOME

TINSLEY LABORATORIES has installed, at Ames Observatory in Texas, this astronomical telescope with a special attachment to track future, distant satellites. The combination Newtonian-Cassegrainian reflector, designed and manufactured by Tinsley, has a 12-inch aperture and weighs about 1,000 pounds. Seven motors are incorporated into the telescope; a combination of three motors gives any rate from star speed to satellite speed. The entire mechanism is mounted on a hydraulic lift, to raise or lower it for easy observing.

Tinsley Laboratories is pleased to assist both the private and professional astronomer by designing and producing optical instruments for every need.



Photos by Jim Thomas

ASTRO-DOME has erected this 10-foot dome to house the Ames Observatory telescope. The 8,000-pound dome is motor driven, rotating in a complete 360-degree circle, and has a full-sized entrance door. It has double transverse shutters with special snow guards — a new feature of all Astro-Domes.

Astro-Dome can provide a variable-drive dome, with slow or high speeds which are controlled by the telescope operator. A synchronously driven dome is also available, to turn automatically with the telescope as it follows an object across the sky.

Whatever your telescope housing needs, Astro-Dome can manufacture domes up to 72 feet in diameter for any type of telescope. May we assist you with your installation?

ASTRO-DOME INCORPORATED

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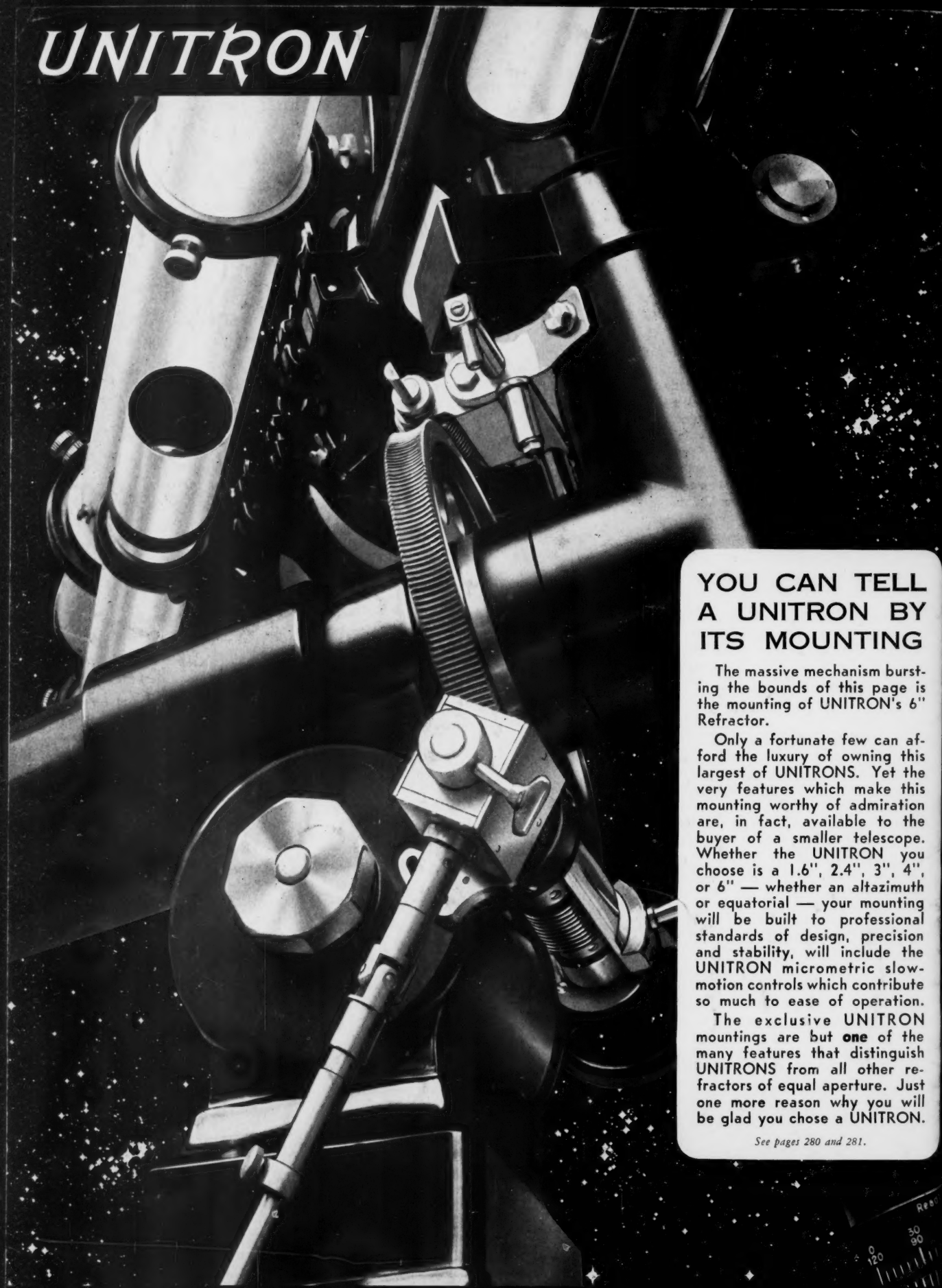

YOU CAN TELL A UNITRON BY ITS MOUNTING

The massive mechanism bursting the bounds of this page is the mounting of UNITRON's 6" Refractor.

Only a fortunate few can afford the luxury of owning this largest of UNITRONS. Yet the very features which make this mounting worthy of admiration are, in fact, available to the buyer of a smaller telescope. Whether the UNITRON you choose is a 1.6", 2.4", 3", 4", or 6" — whether an altazimuth or equatorial — your mounting will be built to professional standards of design, precision and stability, will include the UNITRON micrometric slow-motion controls which contribute so much to ease of operation.

The exclusive UNITRON mountings are but **one** of the many features that distinguish UNITRONS from all other refractors of equal aperture. Just one more reason why you will be glad you chose a UNITRON.

See pages 280 and 281.

UNITRON

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